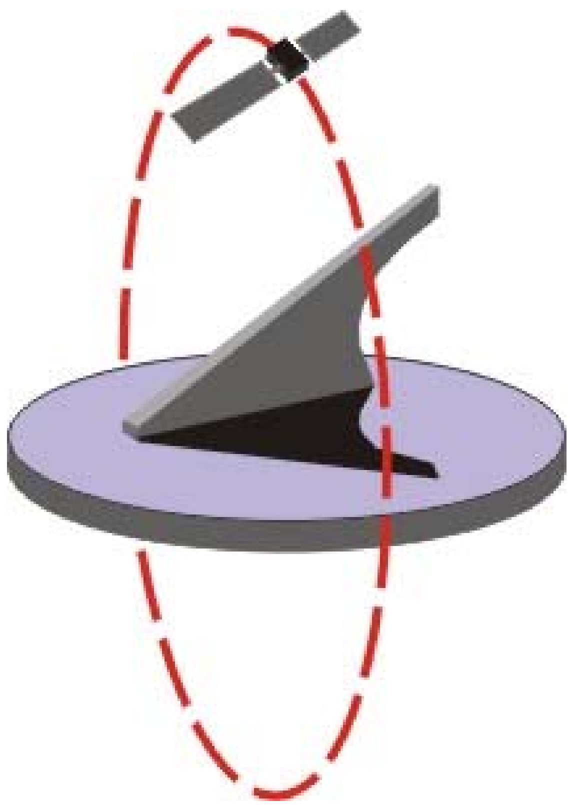
1769HP-GPS

USER MANUAL



Rev 1.1 – June 2005

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CHAPTER 1 INTRODUCTION

The 1769HP-GPS module provides accurate time and position information and services for the Allen-Bradley 1769 platform (CompactLogix or MicroLogix 1500).

The module makes use of Global Positioning System (GPS) technology to derive accurate time which is synchronized with the atomic clocks located on the GPS satellites.

This document serves to describe the functionality, installation, configuration and use of the module.

CHAPTER 2 MODULE ACCESSORIES

Each 1769HP-GPS package includes the following components:

- **1769HP-GPS module**
- **5m RG58 patch lead with a SMA male and TNC male connector on either end**
- **3.3V active 50Ω bullet antenna**
- **1769HP-GPS user manual**

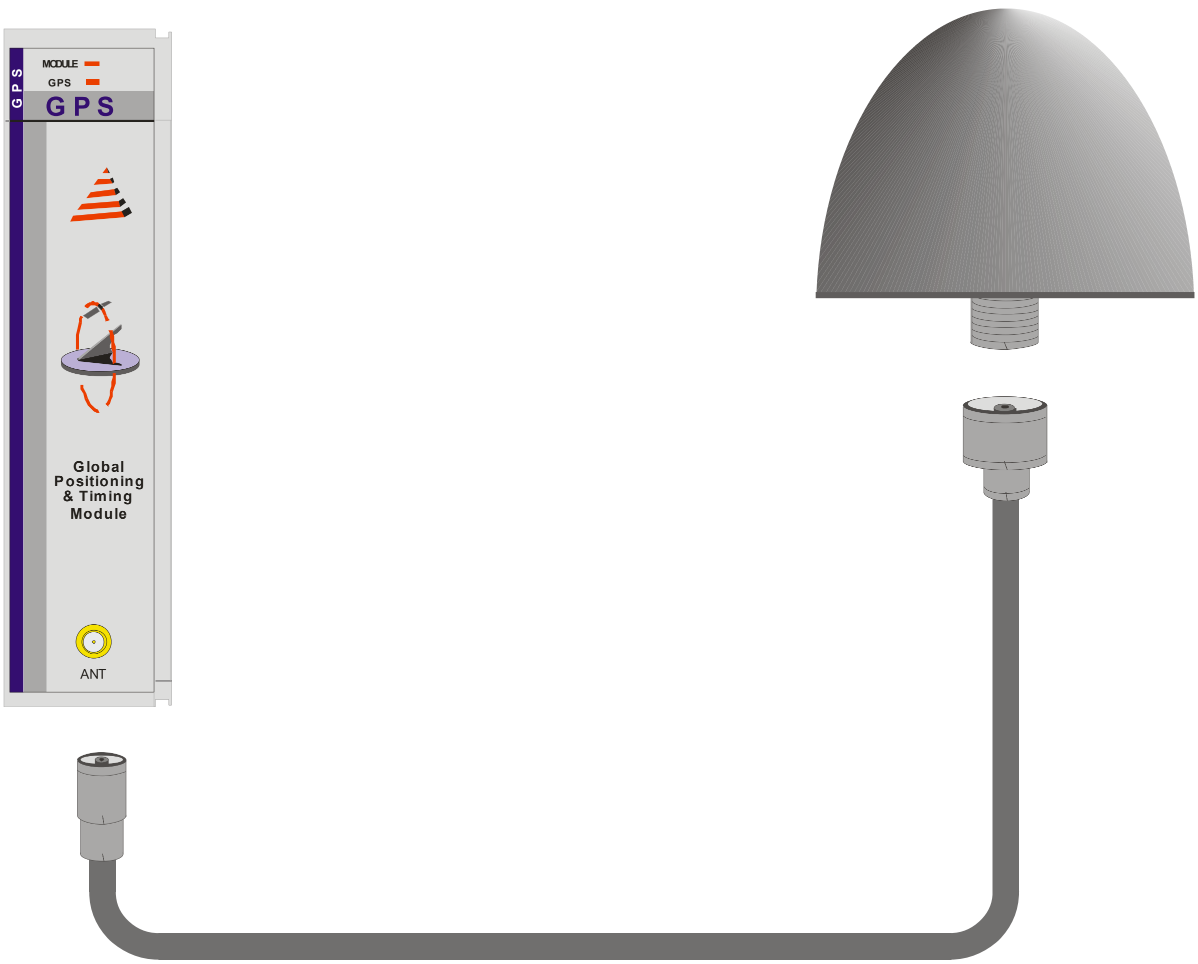


Figure 2.1 : 1769HP-GPS module with antenna and patch-lead

CHAPTER 3 MODULE OPERATION

The 1769HP-GPS module is designed to operate within the Allen-Bradley 1769 backplane. All power required for the module's operation is derived from the 1769 backplane.

Figure 3.1 : 1769HP-GPS Layout

The on-board GPS receiver is connected via the external SMA antenna port and external antenna patch-lead to the active GPS antenna. Once the module is powered-up it will begin searching for available GPS satellites. Soon after lock on at least 4 satellites has been achieved the module's internal time will become valid.

The current status of the module is conveyed to the user by means of the 2 bi-color Status LED's.

The following information is available to the user directly across the backplane by means of a scheduled connection:

- Date and Time in Gregorian Format (year, month, day, hour, minute etc.)
- GPS Receiver Status
- Number of satellites being tracking
- Position in Polar Coordinates (latitude, longitude and altitude)
- Position in Cartesian Coordinates (Earth-centered-earth-fixed X,Y,Z axis)
- Velocity in Polar Coordinates (Northerly, Easterly and Upward)
- Velocity in Cartesian Coordinates (Earth-centered-earth-fixed X,Y,Z axis)

All time and date information can be adjusted to the local time-zone by configuring the Time-Zone offset, in the scheduled output image.

CHAPTER 4 INSTALLING THE MODULE

GPS utilizes a spread spectrum signal in the 1.5GHz range, and thus cannot penetrate conductive or opaque surfaces. Thus the antenna should be mounted in a horizontal position with an unobstructed view of the sky.

Attach the antenna patch lead to the antenna. It is recommended that waterproofing tape be used to seal the connection.

NOTE: Should a longer patch lead be required it is recommended that a GPS signal booster is used. Contact your local Hiprom Technologies distributor for assistance.

Attach the patch lead SMA (male) to the module's SMA (female) connector. It is not recommended that the antenna patch lead exceed a total loss of 10dB at 1.5GHz, as this may increase the time to GPS lock, or in extreme cases, prevent GPS lock from being achieved at all.

Once the module has been power up for the first time, it will search for satellites from a cold start (i.e no almanac). The module will take approximately 5 minutes to acquire Lock. Once a complete almanac has been downloaded, the time to achieve fix will be reduced to around 45 seconds.

CHAPTER 5 CONFIGURING THE MODULE

The 1769HP-GPS module is supported by Allen Bradley's MicroLogix 1500 and CompactLogix PLC systems. Because the CompactLogix uses RSLogix 5000 and the MicroLogix 1500 uses RSLogix 500, two different setup procedures are explained below.

5.1 CompactLogix (RSLogix 5000)

A direct connection between the controller and the 1769HP-GPS module is required to transfer I/O data to and from the module. In addition the module supports various unconnected messages that can be used to retrieve particular information.

Establishing the Direct Connection

This section describes the procedures necessary to configure the 1769HP-GPS module within the CompactLogix system.

The 1769 Generic Module is used in RSLogix5000 to configure the module. The configuration of the module is detailed in the table below.

Data Format		
CommFormat	Data – INT	
Connection parameters		
Description	Instance	Size
Input	101	19
Output	100	4
Configuration	102	0

Table 5.1 : 1769HP-GPS connection parameters.

RPI	
Request Packet Interval	1 ms

Table 5.2 : Local CompactBus connection parameters.

The steps required to add a new 1769HP-GPS module are detailed below.

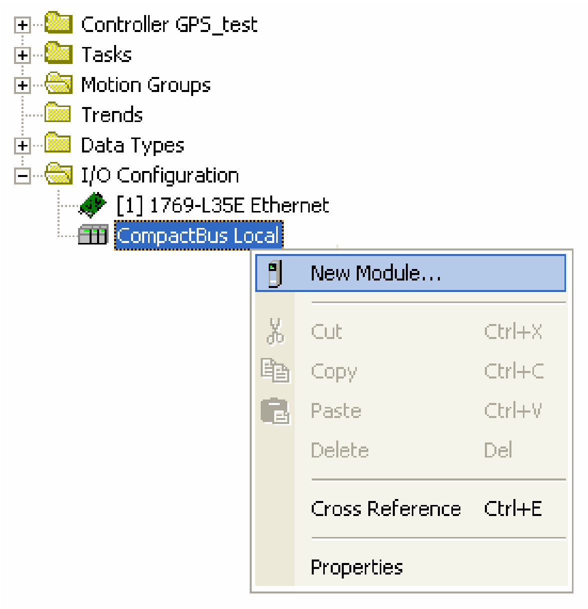


Figure 5.1 : Right-click on I/O Configuration and select New Module

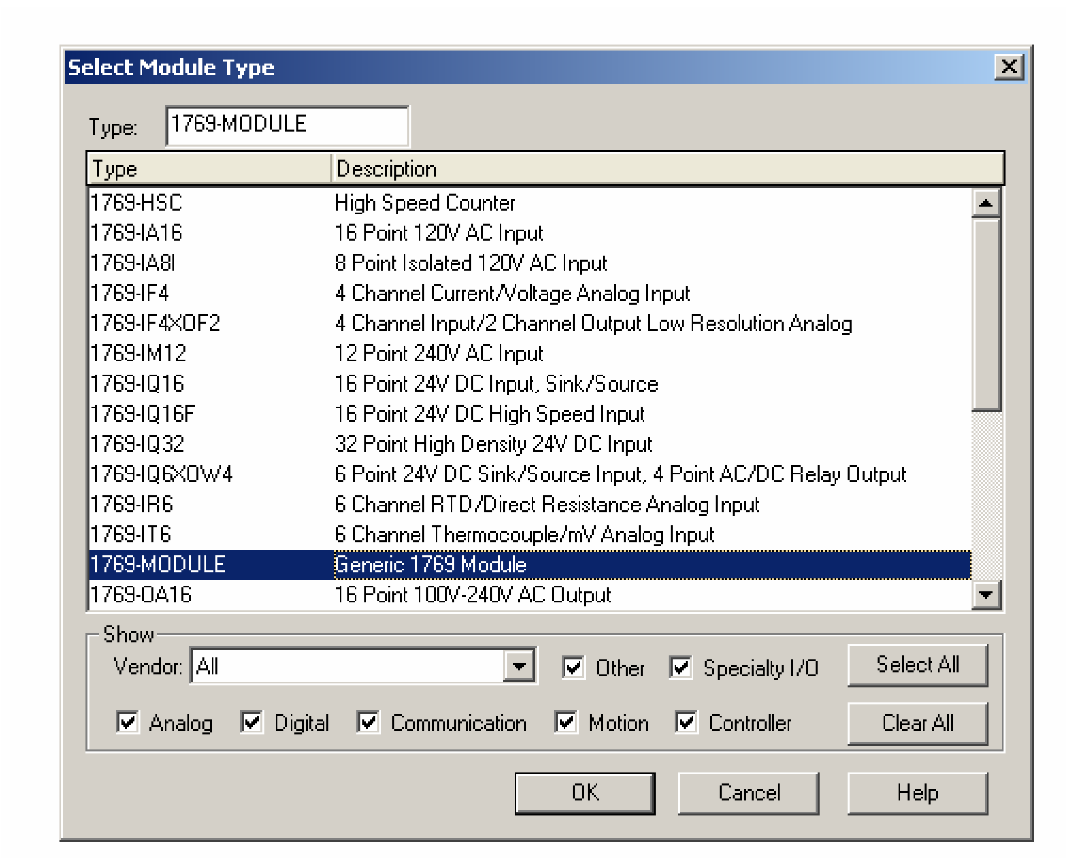


Figure 5.2 : Select Generic 1769 Module (1769HP-GPS MODULE)

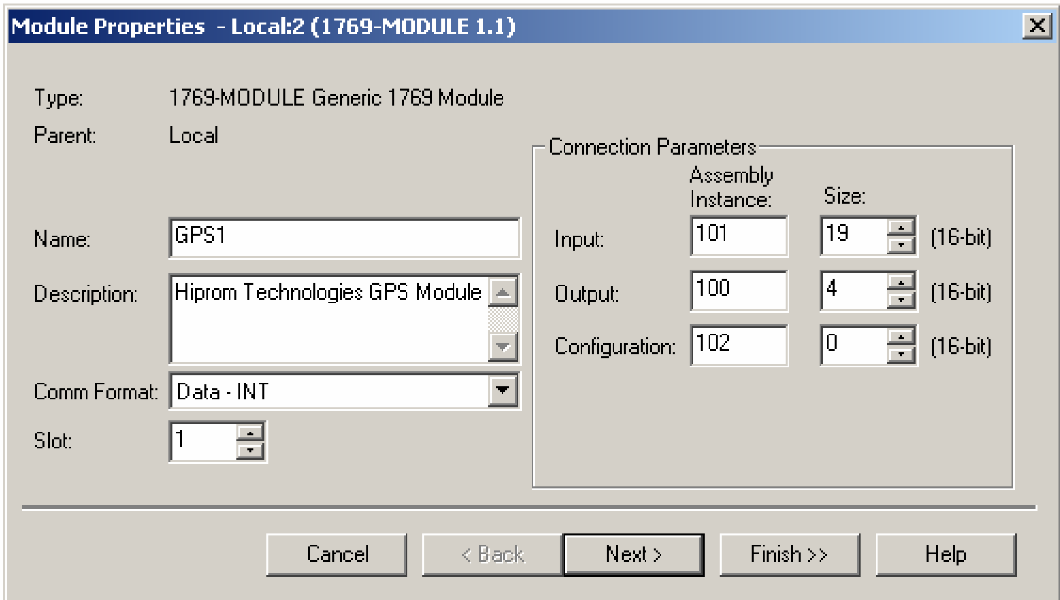


Figure 5.3 : Configure module's parameters

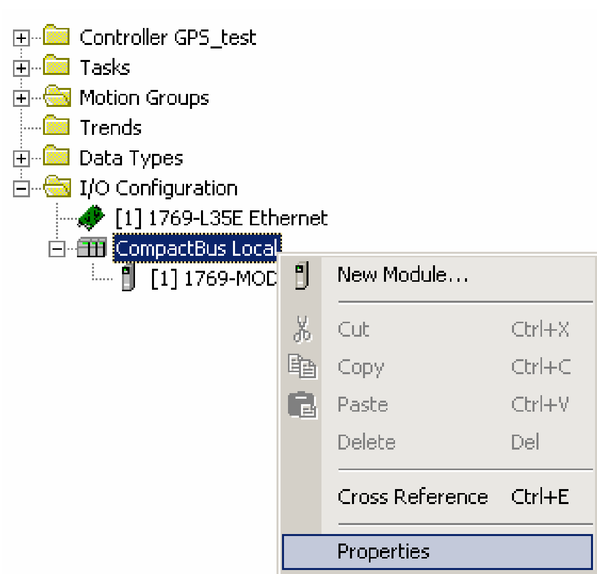


Figure 5.4 : Right-click on CompactBus Local and select Properties

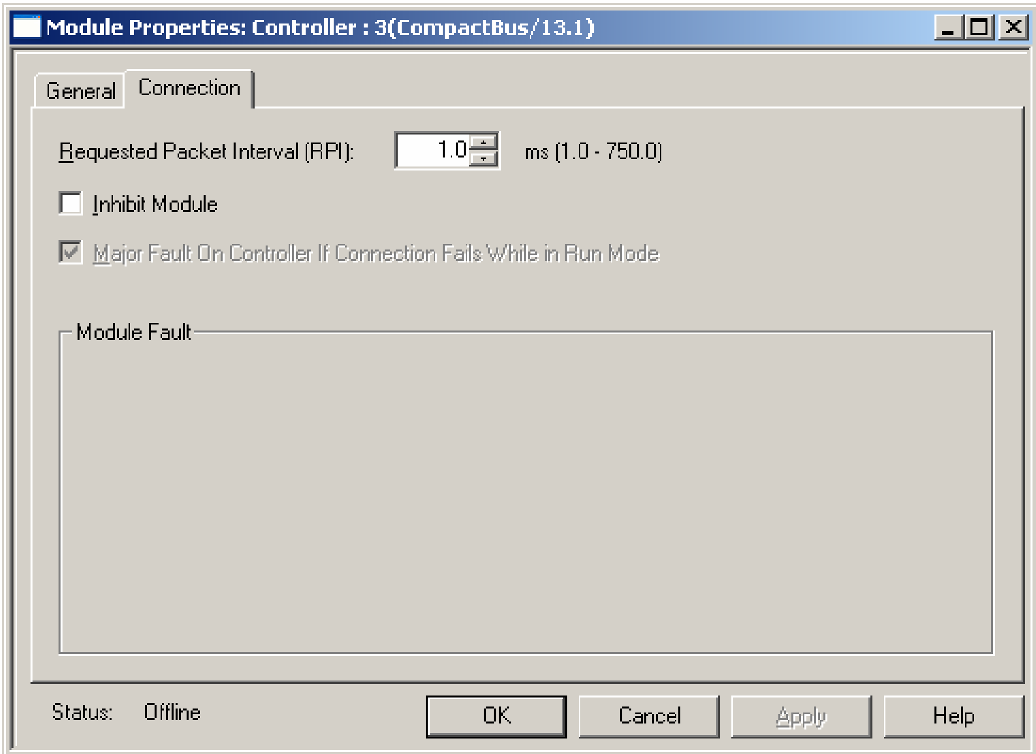


Figure 5.5 : Configure CompactBus module's RPI (Requested Packet Interval)

Once a modules configuration data has been downloaded to the controller, it will attempt to establish a connection with the module. A connection will fail if there is inappropriate configuration data.

5.2 MicroLogix 1500 (RSLogix 500)

A direct connection between the controller and the 1769HP-GPS module is required to transfer I/O data to and from the module.

Establishing the Direct Connection

This section describes the procedures necessary to configure the 1769HP-GPS module within the MicroLogix 1500 system.

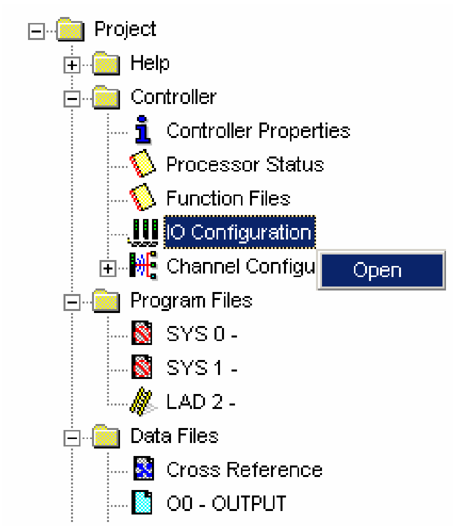


Figure 5.6 : Right-click on I/O Configuration and select Open

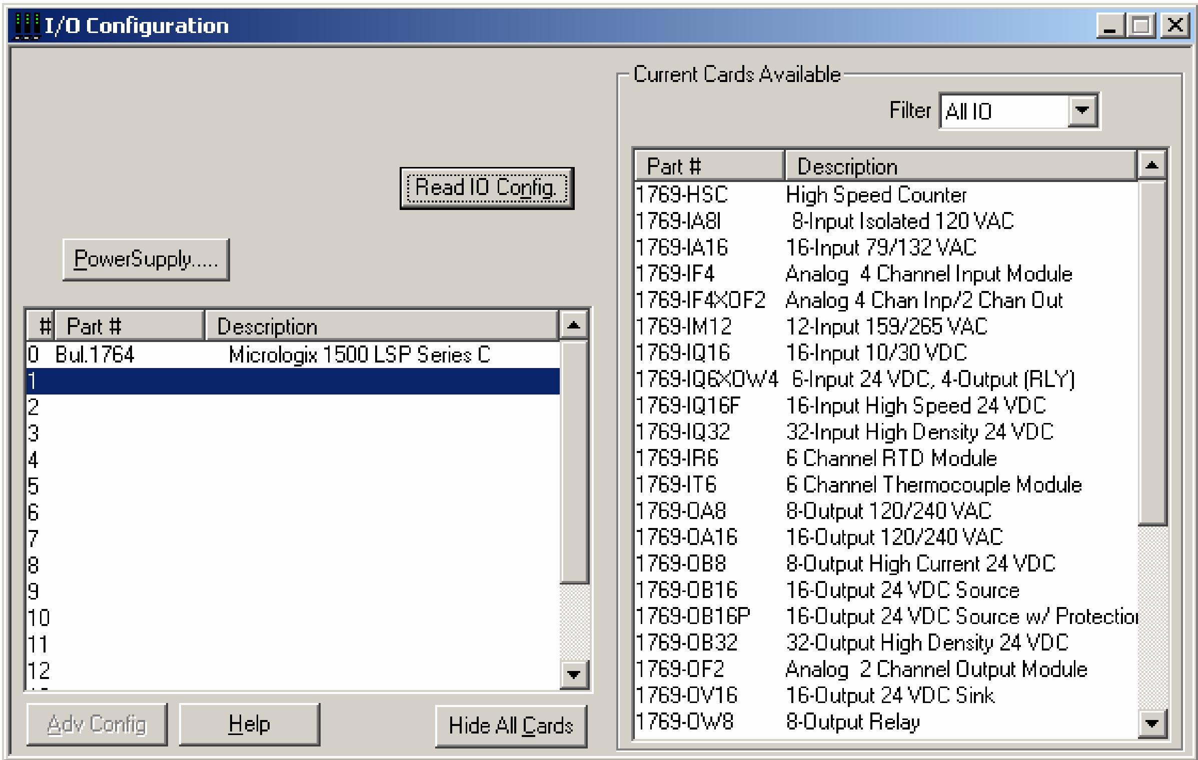


Figure 5.6 : Left-click on Read I/O Config

Before the IO can be read, a connection must be established between RSLogix and the PLC system (Micrologix 1500).

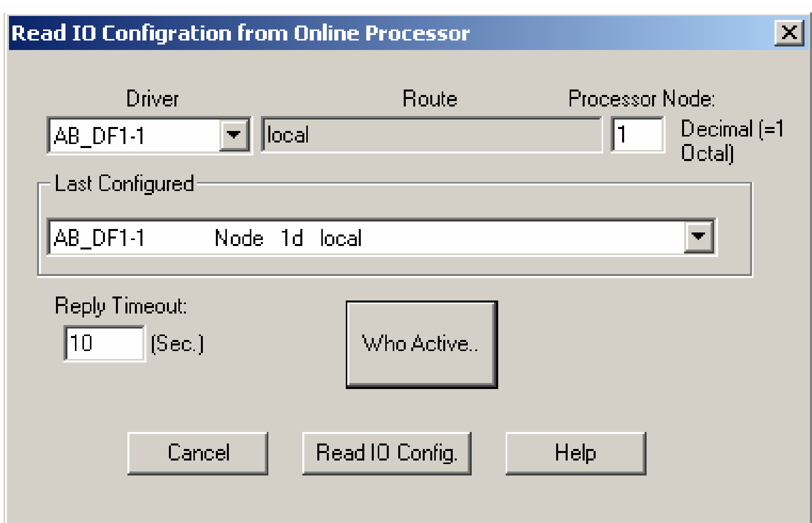


Figure 5.7 : Left-click on Read I/O Config

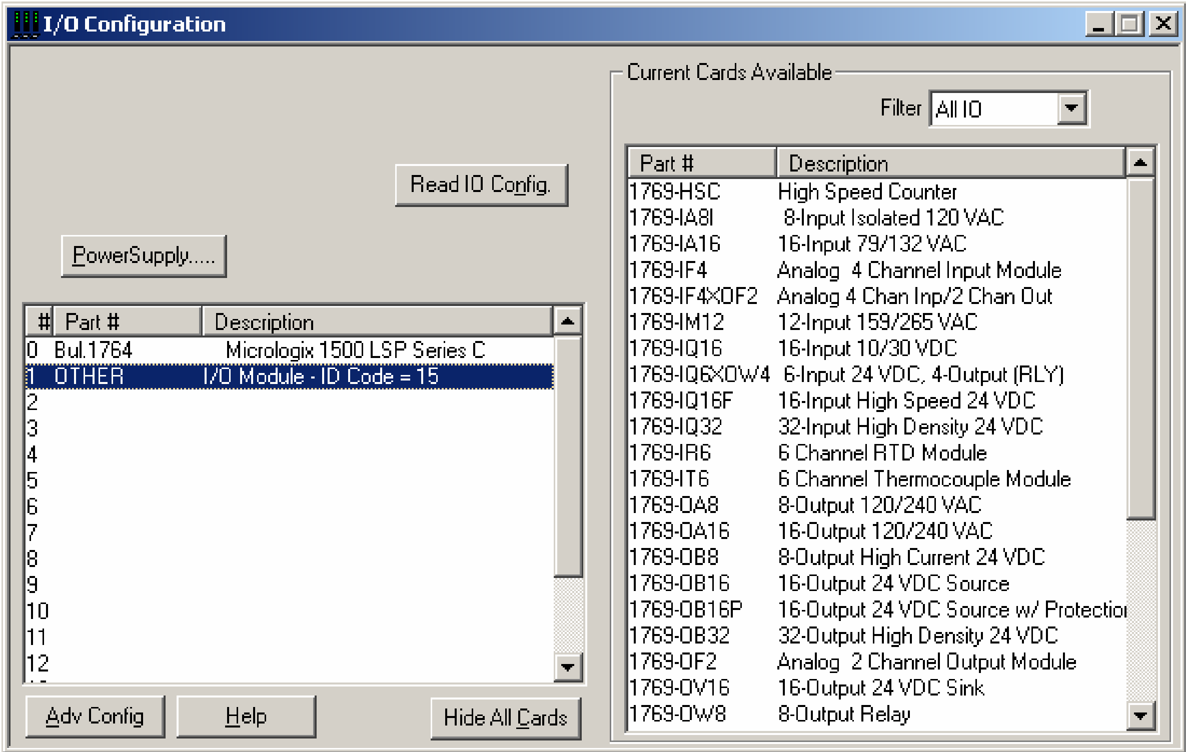


Figure 5.8 : Confirmation that the 1769HP-GPS module has been identified

CHAPTER 6 I/O ADDRESS MAP

The input and output image of the 1769HP-GPS module is defined in the following sections. Appendix A and B provide example code and recommended structures that can be used to extract and view the data.

Input Image

Word	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	NSH	EWH	PEC	SV Count				DTV	RSV	ANT	BAT	PDP	PPS	RSV	LOC	SKY
1	Milliseconds															
2	Seconds															
3	Minutes															
4	Hours															
5	Day															
6	Month															
7	Year															
8	Latitude (Sec x 100)								Pos X (1 x meters)							
9	Latitude (Minutes)								Pos X (10,000 x meters)							
10	Longitude (Sec x 100)								Pos Y (1 x meters)							
11	Longitude (Minutes)								Pos Y (10,000 x meters)							
12	Altitude (1 x meters)								Pos Z (1 x meters)							
13	Altitude (10,000 x meters)								Pos Z (10,000 x meters)							
14	Velocity North (m/s x 10)								Velocity X (m/s x 10)							
15	Velocity East (m/s x 10)								Velocity Y (m/s x 10)							
16	Velocity Up (m/s x 10)								Velocity Z (m/s x 10)							
17	Channel			SV PRN					SV Signal Strength							
18	Reserved															

Figure 6.1 : Connected Input Image

Input Image Description

Field/Value	Description	Location	Type
SKY	**Visible Sky** 0 = Sky not visible or no satellite signals present 1 = Satellite signals available No sky usually indicates that the antenna does not have a clear view of the sky, such as in a building, etc.	**CompactLogix: Local:s:I.Data[0].0** **MicroLogix 1500: I:e.0/0**	BIT
LOC	**Satellite Lock** 0 = Not tracking sufficient satellites to provide positional fix 1 = Sufficient satellites being tracked to provide positional fix Typically, tracking 4 satellites is sufficient to provide lock.	**CompactLogix: Local:s:I.Data[0].1** **MicroLogix 1500: I:e.0/1**	BIT
RSV	**Reserved for future use**	**CompactLogix: Local:s:I.Data[0].2** **MicroLogix 1500: I:e.0/2**	BIT
PPS	**Pulse per Second** This bit transitions from 0 to 1 precisely every second. The pulse duty cycle is approximately 50%.	**CompactLogix: Local:s:I.Data[0].3** **MicroLogix 1500: I:e.0/3**	BIT
PDP	**PDOP OK** 0 = Position Dilution of Precision is unacceptable 1 = No Position Dilution of Precision present Position Dilution of Precision occurs when although there are sufficient satellites in lock, 2 or more of them appear to occupy similar positions in the sky and thus the number of effective satellites is decreased.	**CompactLogix: Local:s:I.Data[0].4** **MicroLogix 1500: I:e.0/4**	BIT
BAT	**Battery Backup on Boot** 0 = No battery backup available on boot-up. 1 = Battery backup available on boot-up. With battery backup enabled the time taken for the GPS module to regain satellite lock is greatly reduced.It is recommended that if the module is not to be used for an extended period that the battery backup be disabled.	**CompactLogix: Local:s:I.Data[0].5** **MicroLogix 1500: I:e.0/5**	BIT
ANT	**Antenna OK** 0 = Antenna Fault 1 = Antenna OK An Antenna fault will occur if the antenna is not present or has been damaged.	**CompactLogix: Local:s:I.Data[0].6** **MicroLogix 1500: I:e.0/6**	BIT
RSV	**Reserved for future use**	**CompactLogix: Local:s:I.Data[0].7** **MicroLogix 1500: I:e.0/7**	BIT

DTV	**Date / Time Valid** 0 = Date Time Not Valid 1 = Date Time synchronized with GPS	**CompactLogix:** **Local:s:I.Data[0].8** **MicroLogix 1500:** **I:e.0/8**	BIT
SV Count	**Satellite count** Number of Satellites currently being tracked	**CompactLogix:** **Local:s:I.Data[0].9-12** **MicroLogix 1500:** **I:e.0/9-12**	BIT
PEC	**Last Position Vector in ECEF Mode** 0 = Position Update in Latitude, Logtitude and Altitude format 1 = Position Update in Earth-Centred-Earth-Fixed X,Y,Z format ECEF Mode can be invoked by setting the ECF bit in the output image. (MicroLogix 1500: O:e.0/1 or CompactLogix: Local:s:O.Data[0].1)	**CompactLogix:** **Local:s:I.Data[0].13** **MicroLogix 1500:** **I:e.0/13**	BIT
EWH	**Current East / West Hemisphere** 0 = Current position in East hemishere 1 = Current position in West hemisphere This flag is Not valid when in ECEF mode is invoked.	**CompactLogix:** **Local:s:I.Data[0].14** **MicroLogix 1500:** **I:e.0/14**	BIT
NSH	**Current North / South Hemisphere** 0 = Current position in North hemishere 1 = Current position in South hemisphere This flag is Not valid when in ECEF mode is invoked.	**CompactLogix:** **Local:s:I.Data[0].15** **MicroLogix 1500:** **I:e.0/15**	BIT
Milliseconds	**Real Time Milliseconds** Current real time Milliseconds (0 - 999)	**CompactLogix:** **Local:s:I.Data[1]** **MicroLogix 1500:** **I:e.1**	INT
Seconds	**Real Time Seconds** Current real time Seconds (0 - 59)	**CompactLogix:** **Local:s:I.Data[2]** **MicroLogix 1500:** **I:e.2**	INT
Minutes	**Real Time Minutes** Current Local time Minutes (0 - 59) This is dependent on the configured time zone (MicroLogix 1500: O:e.1 or CompactLogix: Local:s:O.Data[1])	**CompactLogix:** **Local:s:I.Data[3]** **MicroLogix 1500:** **I:e.3**	INT
Hours	**Real Time Hours** Current Local time Hours (0 - 23) This is dependent on the configured time zone (MicroLogix 1500: O:e.1 or CompactLogix: Local:s:O.Data[1])	**CompactLogix:** **Local:s:I.Data[4]** **MicroLogix 1500:** **I:e.4**	INT
Day	**Calendar Day of Month** Current Local Calendar Day (1 - 31) This is dependent on the configured time zone (MicroLogix 1500: O:e.1	**CompactLogix:** **Local:s:I.Data[5]**	INT

	or CompactLogix: Local:s:O.Data[1])	**MicroLogix 1500: I:e.5**	
Month	**Calendar Month** Current Local Calendar Month (1 - 12) This is dependent on the configured time zone (MicroLogix 1500: O:e.1 or CompactLogix: Local:s:O.Data[1])	**CompactLogix: Local:s:I.Data[6]** **MicroLogix 1500: I:e.6**	INT
Year	**Calendar Year** Current Local Calendar Year This is dependent on the configured time zone (MicroLogix 1500: O:e.1 or CompactLogix: Local:s:O.Data[1])	**CompactLogix: Local:s:I.Data[7]** **MicroLogix 1500: I:e.7**	INT
Latitude (PEC = 0) **Position X** (PEC = 1)	**Current Position Latitude** Degrees = integer (I:e.9 / 60) Minutes = I:e.9 mod 60 Seconds = I:e.8 / 100 Only Valid if the PEC flag (I:e.0/13) = 0 ***OR*** **Distance from Earth-centre along the X - axis.** X-Position = (I:e.8 + (I:e.9 x 10,000)) *in metres* Position is calculated with respect to the WGS-84 Earth-Centred Earth-Fixed co-ordinate system. The X-axis is defined as the vector with origin at the earth's centre and passing through the intersection of the equator and Greenwich meridian. Only Valid if the PEC flag (I:e.0/13) = 1	**CompactLogix: Local:s:I.Data[8] – [9]** **MicroLogix 1500: I:e.8-9**	INT
Longitude (PEC = 0) **Position Y** (PEC = 1)	**Current Position Longitude** Degrees = integer (I:e.11 / 60) Minutes = I:e.11 mod 60 Seconds = I:e.10 / 100 Only Valid if the PEC flag (I:e.0/13) = 0 ***OR*** **Distance from Earth-centre along the Y - axis.** Y-Position = (I:e.10 + (I:e.11 x 10,000) *in metres* Position is calculated with respect to the WGS-84 Earth-Centred Earth-Fixed co-ordinate system. The Y-axis is defined as the vector with origin at the earth's centre and passing through the equator 90 degrees east of the Greenwich meridian. Only Valid if the PEC flag (I:e.0/13) = 1	**CompactLogix: Local:s:I.Data[10] – [11]** **MicroLogix 1500: I:e.10-11**	INT
Altitude (PEC = 0) **Position Z** (PEC = 1)	**Current Position Altiude** Altitude= (I:e.12 + (I:e.13 x 10,000) *in metres* I:e.13 Only Valid if the PEC flag (I:e.0/13) = 0 ***OR*** **Distance from Earth-centre along the Y - axis.** Z-Position = (I:e.10 + (I:e.11 x 10,000) *in metres* Position is calculated with respect to the WGS-84 Earth-Centred Earth-	**CompactLogix: Local:s:I.Data[12] – [13]** **MicroLogix 1500: I:e.12-13**	INT

	Fixed co-ordinate system. The Z-axis is defined as the vector with origin at the earth's centre and passing through the North pole. Only Valid if the PEC flag (I:e.0/13) = 1		
Velocity – North (PEC = 0) **Velocity – X** (PEC = 1)	**Current Northerly Velocity** Velocity North / 10 (*in m/s*) A negative value indicates a Southerly direction of movement. Only Valid if the PEC flag (I:e.0/13) = 0 ***OR*** **Speed with respect to the X - axis.** X-Velocity / 10.0 (*in m/s)* The X-axis is defined as the vector with origin at the earth's centre and passing through the intersection of the equator and Greenwich meridian. Only Valid if the PEC flag (I:e.0/13) = 1	**CompactLogix: Local:s:I.Data[14]** **MicroLogix 1500: I:e.14**	INT
Velocity – East (PEC = 0) **Velocity – Y** (PEC = 1)	**Current Easterly Velocity** Velocity East / 10 (*in m/s*) A negative value indicates a Westerly direction of movement. Only Valid if the PEC flag (I:e.0/13) = 0 ***OR*** **Speed with respect to the Y - axis.** Y-Velocity / 10.0 (*in m/s)* The Y-axis is defined as the vector with origin at the earth's centre and passing through the intersection of the equator and Greenwich meridian. Only Valid if the PEC flag (I:e.0/13) = 1	**CompactLogix: Local:s:I.Data[15]** **MicroLogix 1500: I:e.15**	INT
Velocity – UP (PEC = 0) **Velocity – Z** (PEC = 1)	**Current Upward Velocity** Velocity Up / 10 (*in m/s*) A negative value indicates a Downward direction of movement. Only Valid if the PEC flag (I:e.0/13) = 0 ***OR*** **Speed with respect to the Z - axis.** Z-Velocity / 10.0 (*in m/s)* The Z-axis is defined as the vector with origin at the earth's centre and passing through the intersection of the equator and Greenwich meridian. Only Valid if the PEC flag (I:e.0/13) = 1	**CompactLogix: Local:s:I.Data[16]** **MicroLogix 1500: I:e.16**	INT
Channel	**GPS Receiver Channel Number** These 3 bits indicate which of the GPS's 8 (0-7) channels' data is being displayed. Because all 8 channels' data is passed with a single word, it is time division multiplexed, showing a different channel every second. The channel number can be used as an indirect addressing pointer, to store the Channel SV PRN and Signal Strengths in the PLC.	**CompactLogix: Local:s:I.Data[17].13-15** **MicroLogix 1500: I:e.17/13-15**	INT
SV PRN	**Satellite Vehicle PRN Identification Number tracked on current channel** Each operational GPS satellite has a unique PRN identification number (0-31).	**CompactLogix: Local:s:I.Data[17].8-12** **MicroLogix 1500: I:e.17/8-12**	INT

	Updated in conjuction with "Channel" described above		
SV Signal Strength	**Satellite Signal Strength on current channel** A measure of the satellite signal strength calculated during signal correlation. Signal Strength in (dbHz x 10) after correlation. Updated in conjuction with "Channel" described above	**CompactLogix: Local:s:I.Data[17].0-7** **MicroLogix 1500: I:e.17/0-7**	INT
Reserved	**Reserved for future use**	**CompactLogix: Local:s:I.Data[18]** **MicroLogix 1500: I:e.18**	INT

Output Image

WORD	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Reserved															ECF
1	Time Zone (Hours x 10)															
2	Reserved															
3	Reserved															

Figure 6.2 : Connected Output Image

Output Image Description

Field	Description	Location	Type
ECF	**Select Earth-Centred-Earth-Fixed Mode** Setting this bit causes the module to report position and velocity data in Cartesian co-ordinates. Clearing this bit causes th./e module to report position and velocity data in Polar co-ordinates.	**CompactLogix: Local:s:O.Data[0].0** **MicroLogix 1500: O:e.0/0**	BIT
Time zone	**Time Zone Configuration** Used to set the module to report in local time standard. Time zone = UTC Offest where the UTC Offest is the difference, in hours, between local time and GMT. E.g. For Pacific Standard Time (GMT - 8) set time zone = -8	**CompactLogix: Local:s:O.Data[1]** **MicroLogix 1500: O:e.1**	INT
Reserved	**Reserved for future use**	**CompactLogix: Local:s:O.Data[2] – [3]** **MicroLogix 1500: O:e.2 - 3**	INT

The Time zone needs to be copied from a tag (of type real) into the output word. Appendix A and B provide example code and recommended data types.

CHAPTER 7 MODULE STATUS

The following sections describe the various status of the module and how they may be determined via the 2 bi-color (Green / Red) LEDs.

Status LEDs

LED	DESCRIPTION	STATUS	MEANING
Module	Module Status	Solid Red	Major Hardware Fault
		Flashing Red	Major Fault
		Flashing Green	Minor Fault
		Solid Green	Module operating correctly
GPS	GPS Lock Status	Solid Red	Antenna Failure
		Flashing Red	No Satellite found
		Flashing Green	Busy acquiring satellites
		Solid Green	Full GPS Lock, positioning and time fixing

Table 8.1 : LED status information of the module.

APPENDIX A PLC LADDER EXAMPLE

The 1769HP-GPS module is supported by Allen Bradley's MicroLogix 1500 and CompactLogix PLC systems. Thus ladder examples for RSLogix 500 and RSLogix 5000 are given below.

A.1. RSLogix 500

The ladder example on the following pages consists of the following program files:

LAD 2 (Page: 23)
- Calls all other program files

LAD 3 – POSITION (Page 24-29)
- Extracts position in either Polar or ECEF format

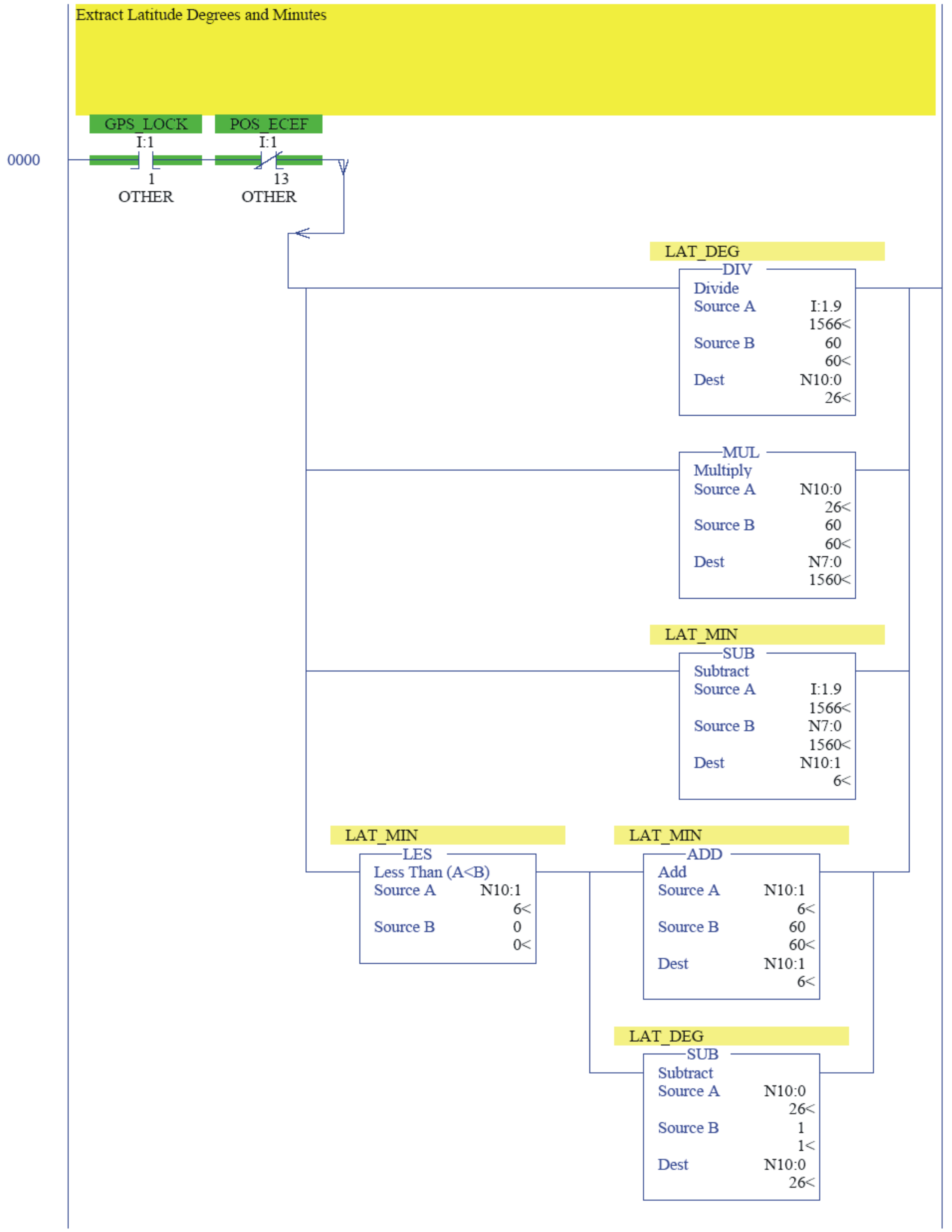
LAD 4 – SIGNAL (Page 30 – 31)
- Extracts the satellite signal strengths for all 8 GPS receiver channels

LAD 5 – CONFIG (Page 32)
- Configures Time Zone

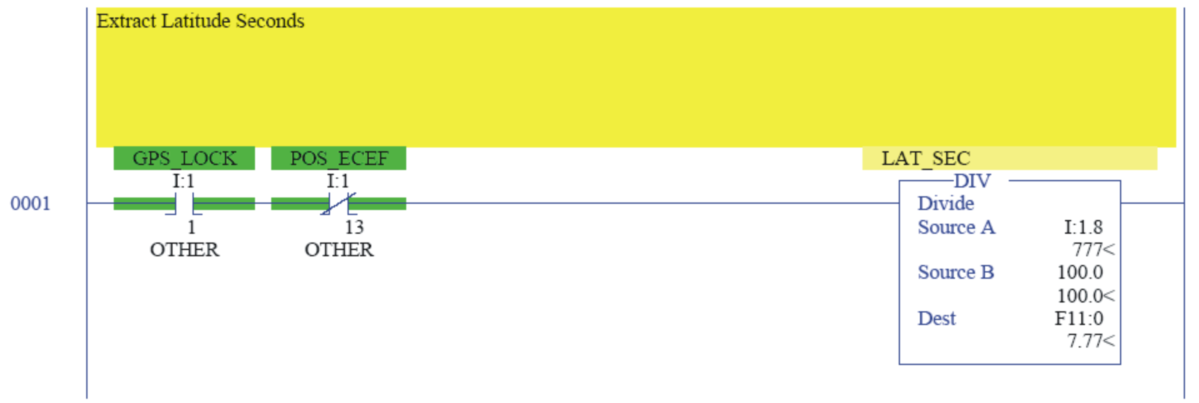
The following example code can be downloaded from the Hiprom website. (www.hiprom.com)

LAD 2 - --- Total Rungs in File = 4

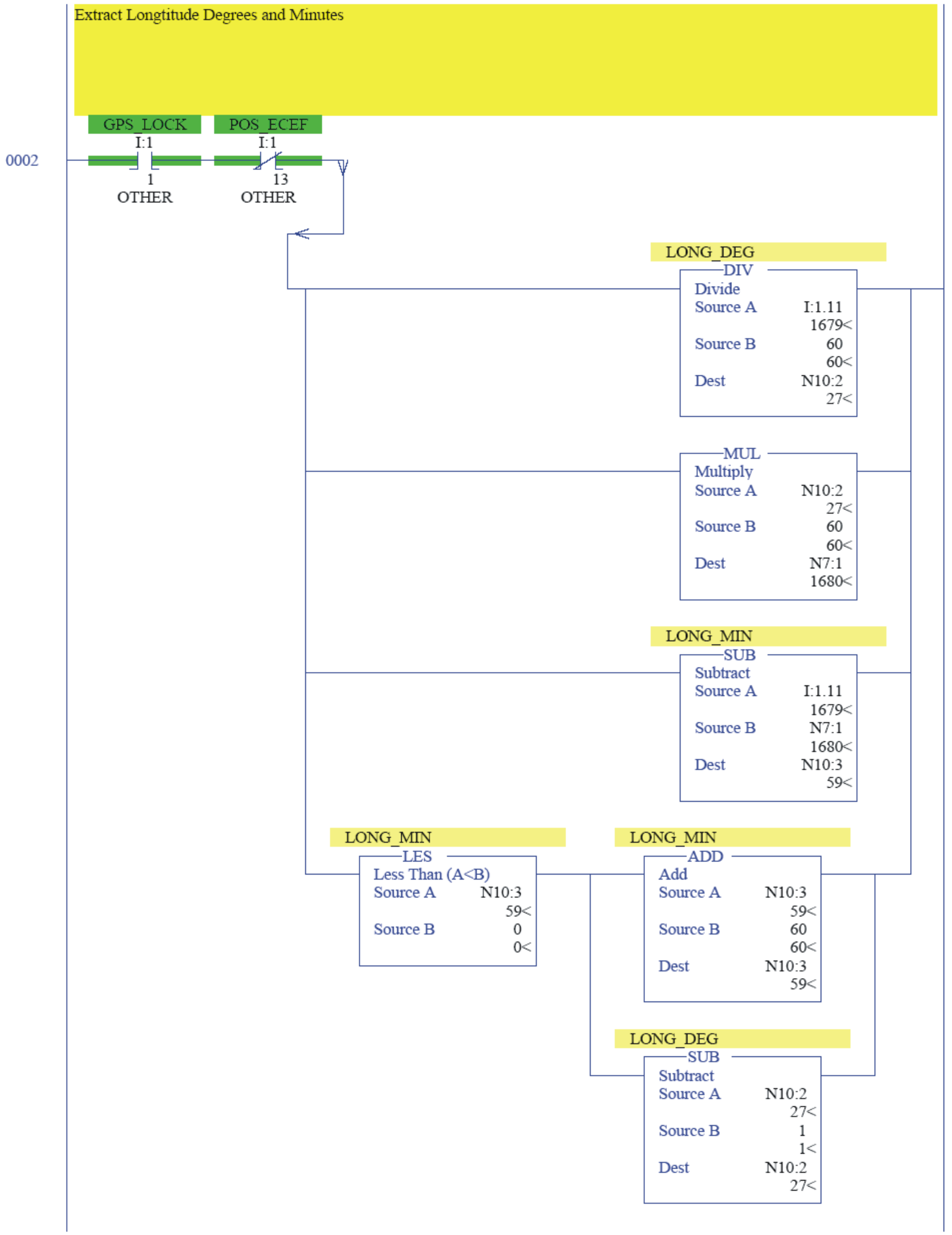
LAD 3 - POSITION - Position extraction --- Total Rungs in File = 10



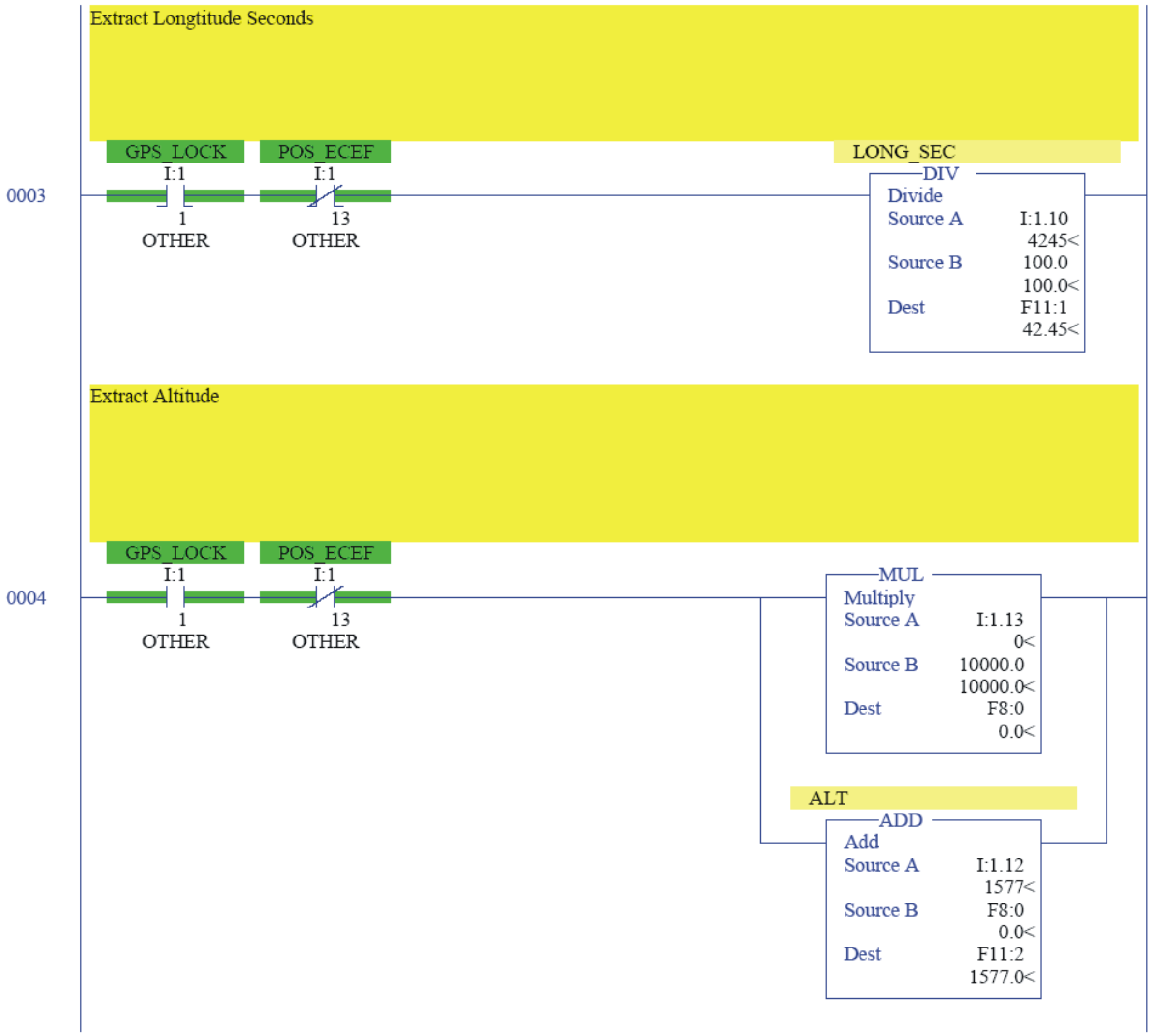
LAD 3 - POSITION - Position extraction --- Total Rungs in File = 10



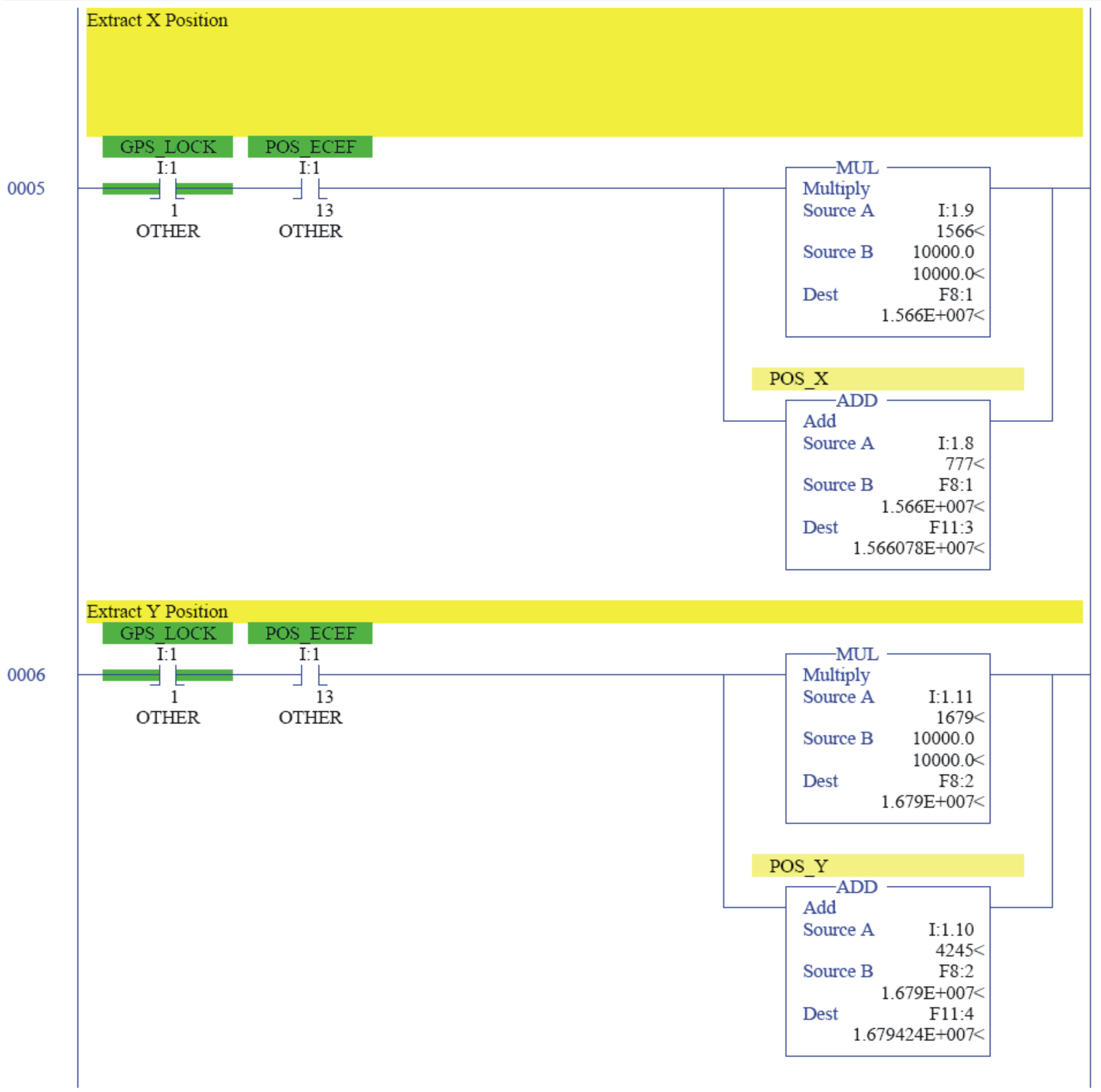
LAD 3 - POSITION - Position extraction --- Total Rungs in File = 10



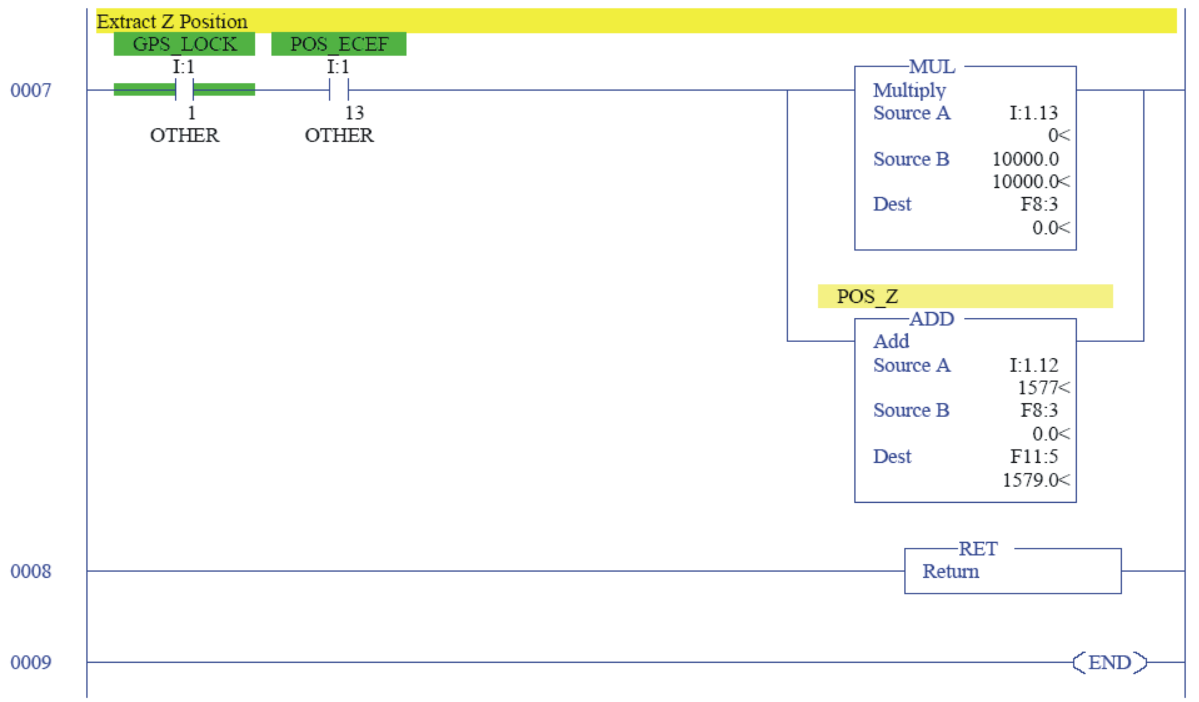
LAD 3 - POSITION - Position extraction --- Total Rungs in File = 10

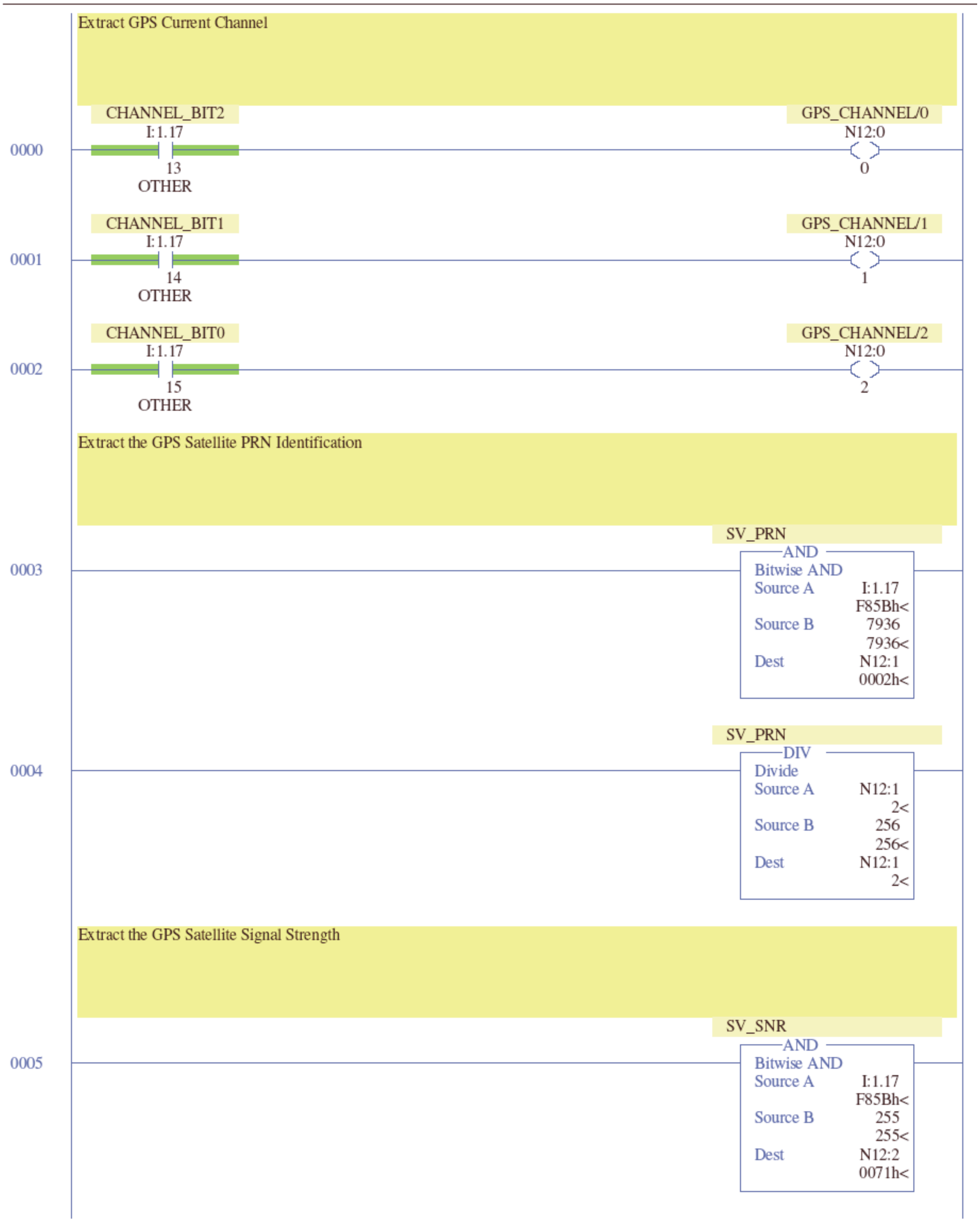


LAD 3 - POSITION - Position extraction --- Total Rungs in File = 10

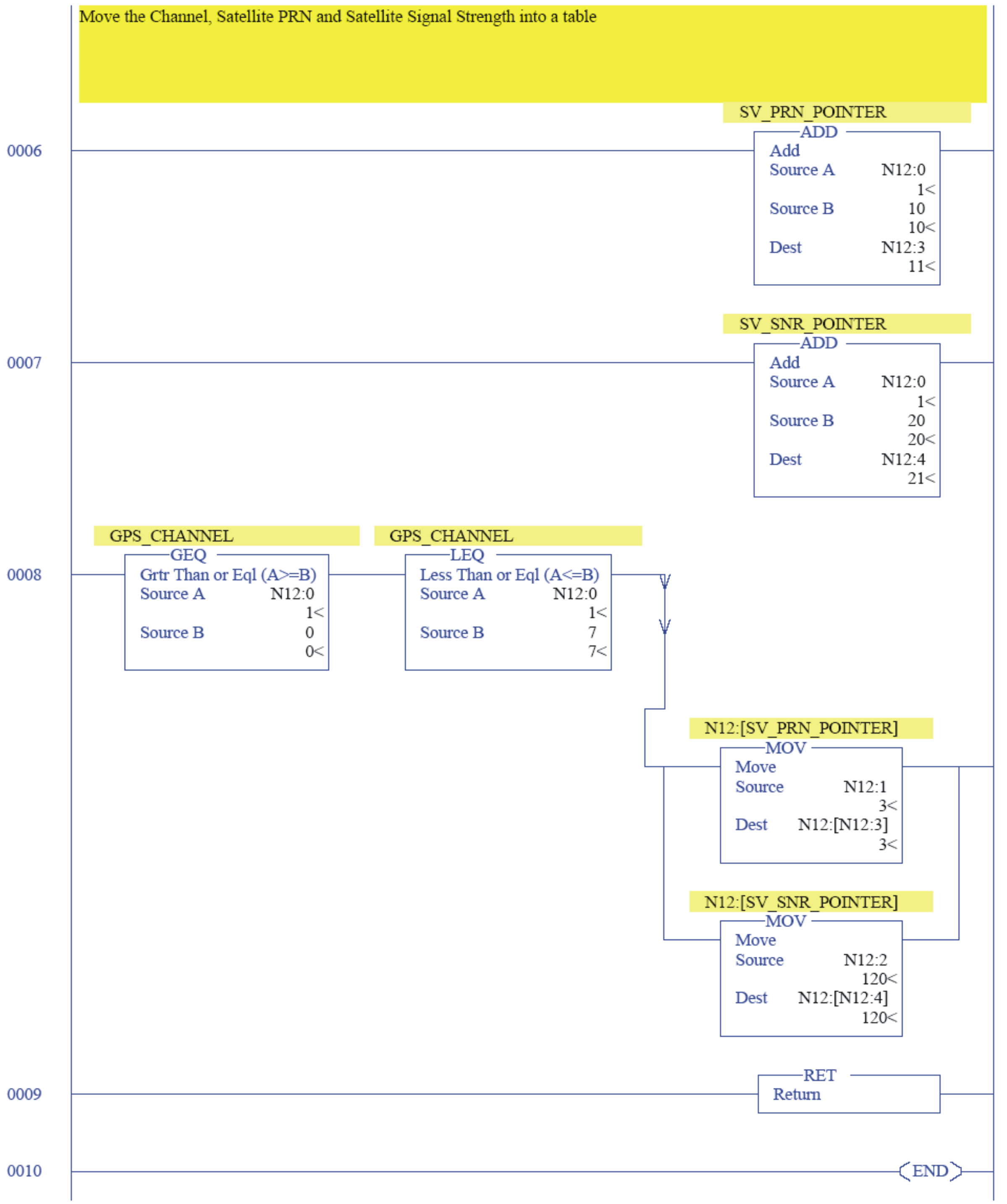


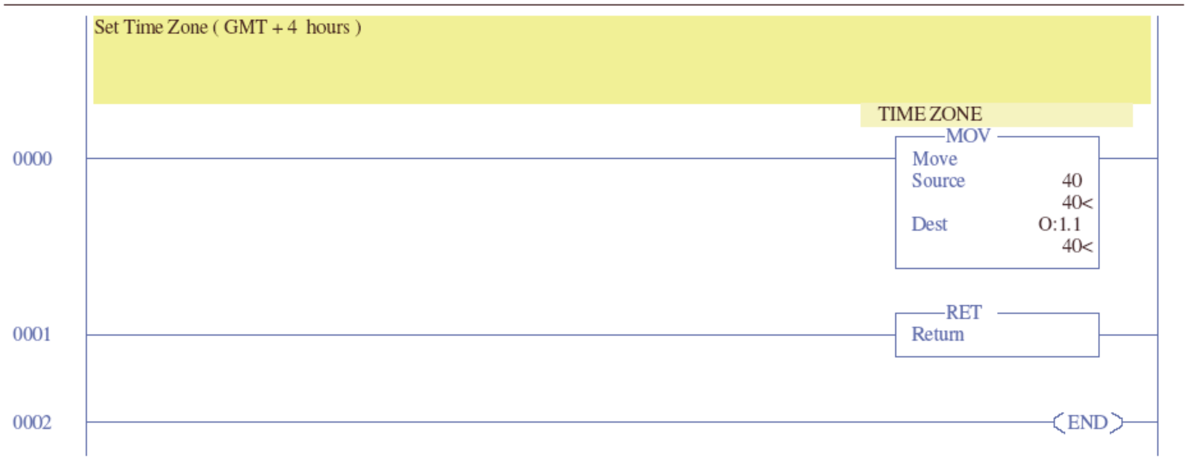
LAD 3 - POSITION - Position extraction --- Total Rungs in File = 10




Extract GPS Current Channel
CHANNEL_BIT2
I:1.17
0000
13
OTHER
GPS_CHANNEL/0
N12:0
0
CHANNEL_BIT1
I:1.17
0001
14
OTHER
GPS_CHANNEL/1
N12:0
1
CHANNEL_BIT0
I:1.17
0002
15
OTHER
GPS_CHANNEL/2
N12:0
2
Extract the GPS Satellite PRN Identification
0003
SV_PRN
AND
Bitwise AND
Source A I:1.17
F85Bh<
Source B 7936
7936<
Dest N12:1
0002h<
0004
SV_PRN
DIV
Divide
Source A N12:1
2<
Source B 256
256<
Dest N12:1
2<
Extract the GPS Satellite Signal Strength
0005
SV_SNR
AND
Bitwise AND
Source A I:1.17
F85Bh<
Source B 255
255<
Dest N12:2
0071h<

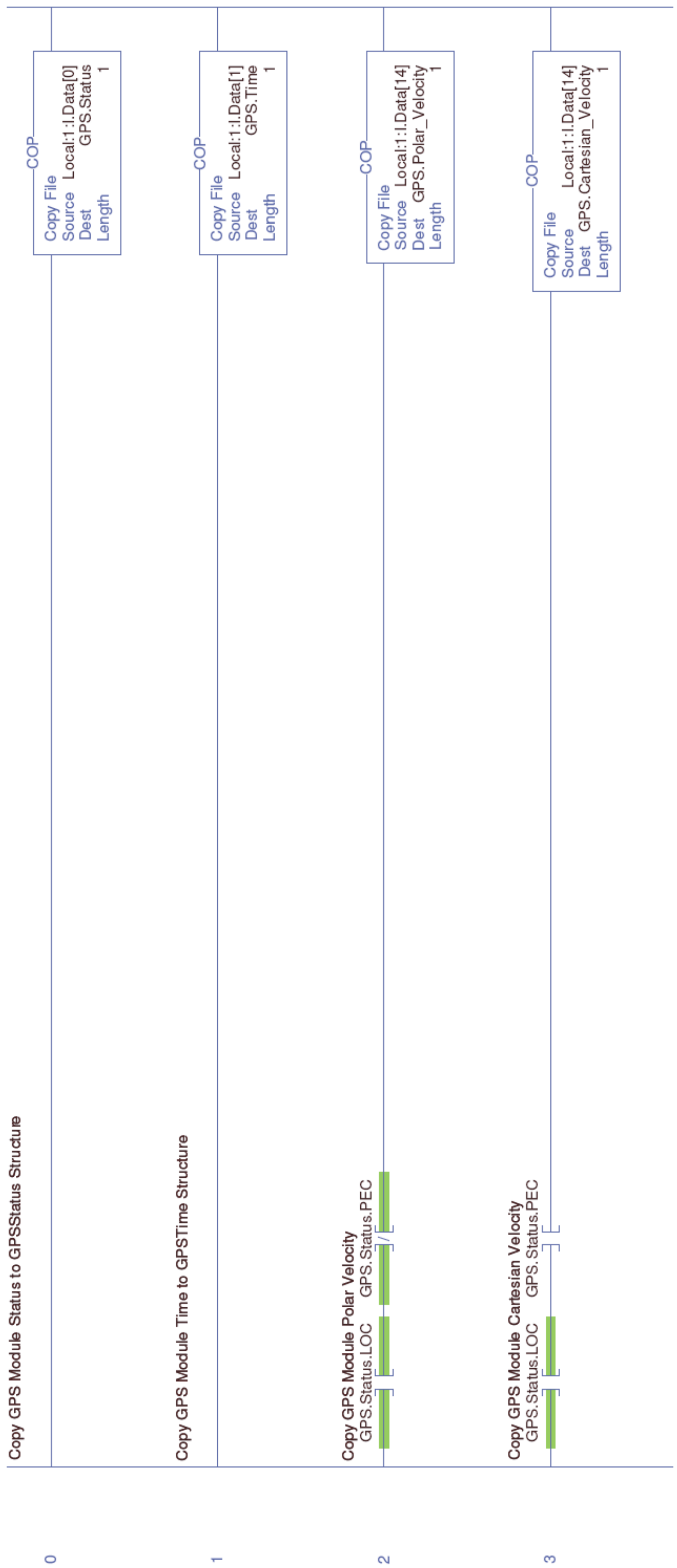
LAD 4 - SIGNAL --- Total Rungs in File = 11

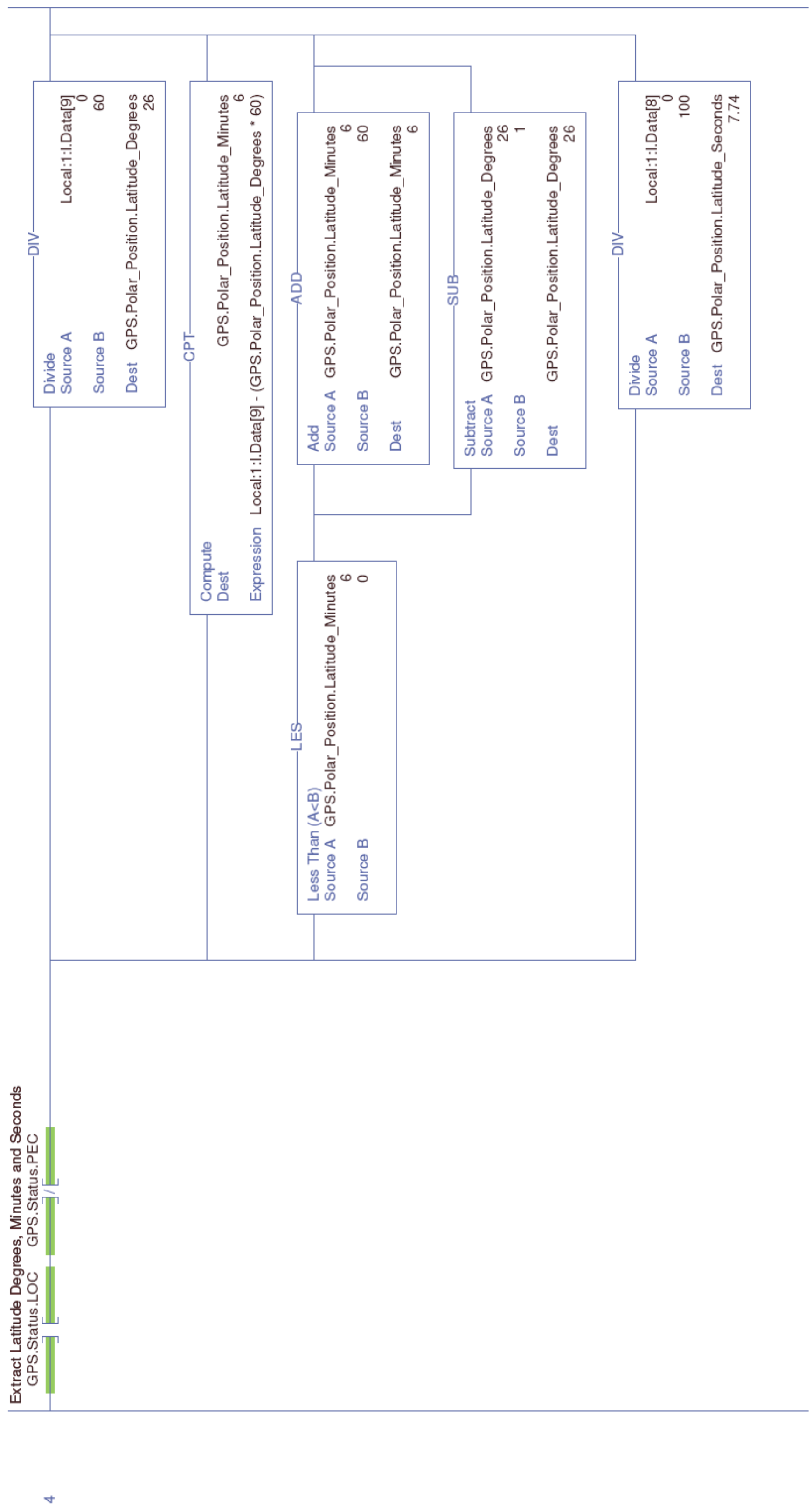


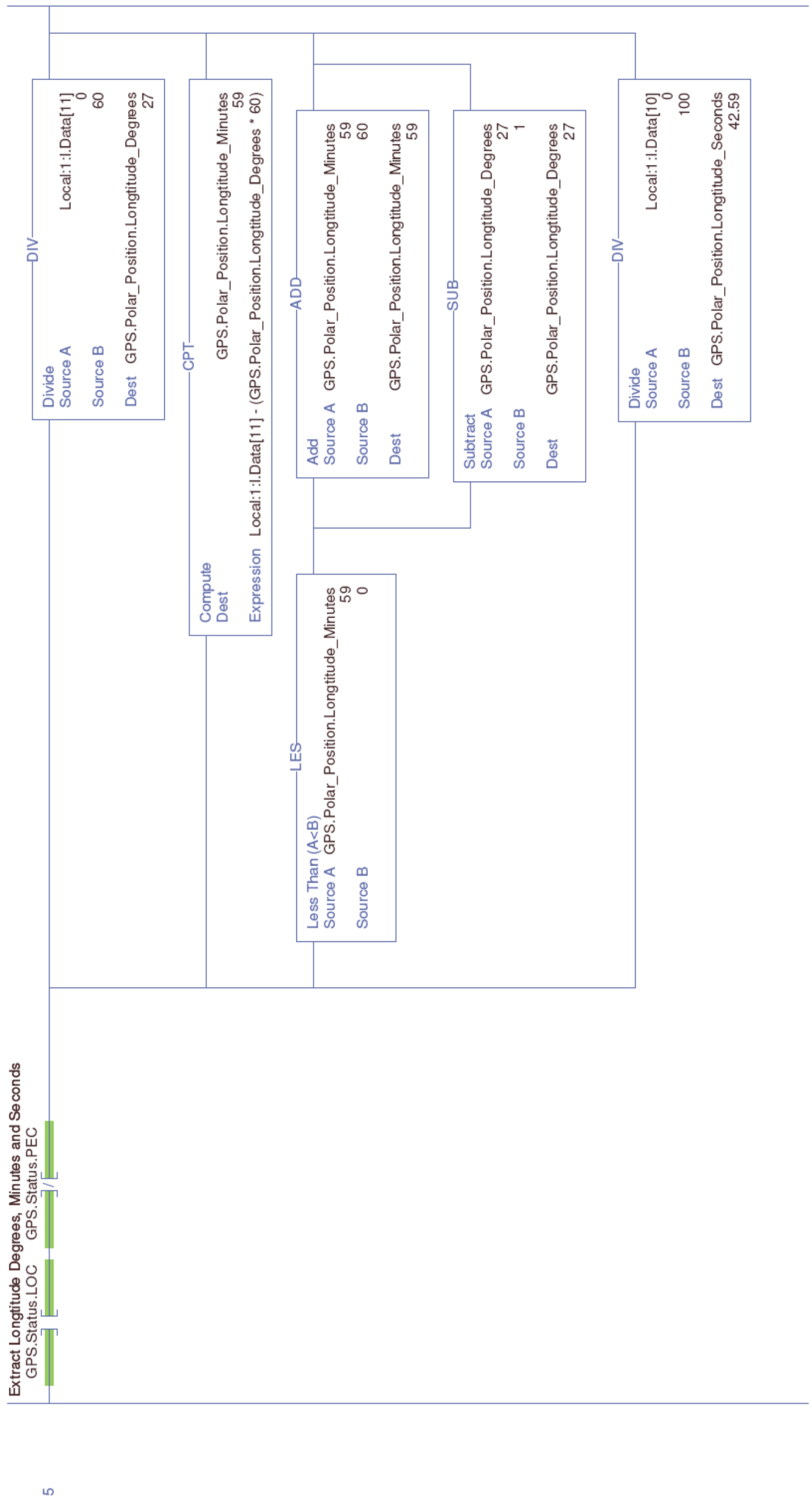

Set Time Zone (GMT + 4 hours)
TIME ZONE
0000
MOV
Move
Source 40
40<
Dest O:1.1
40<
0001
RET
Return
0002
END

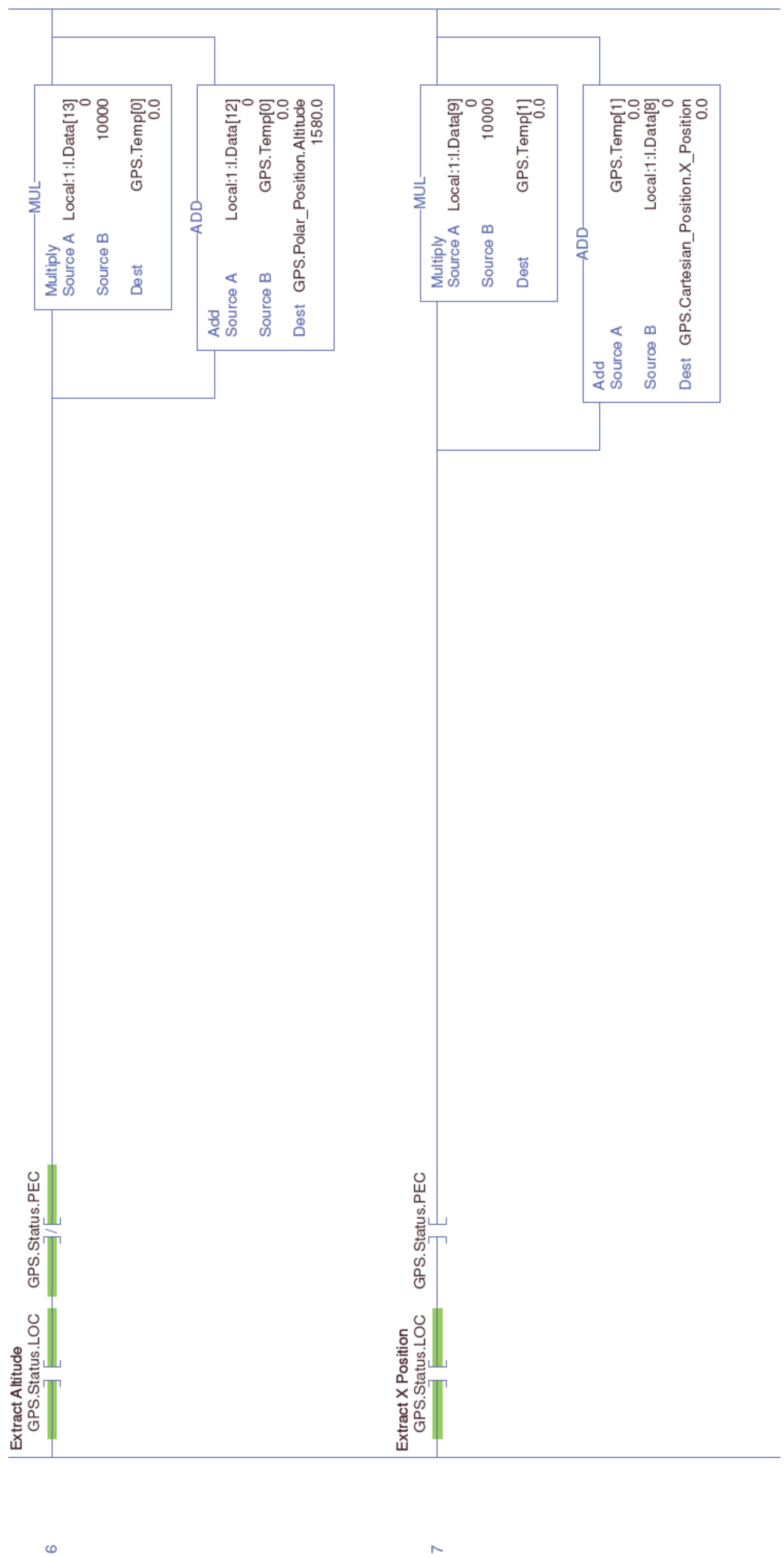
A.2. RSLogix 5000

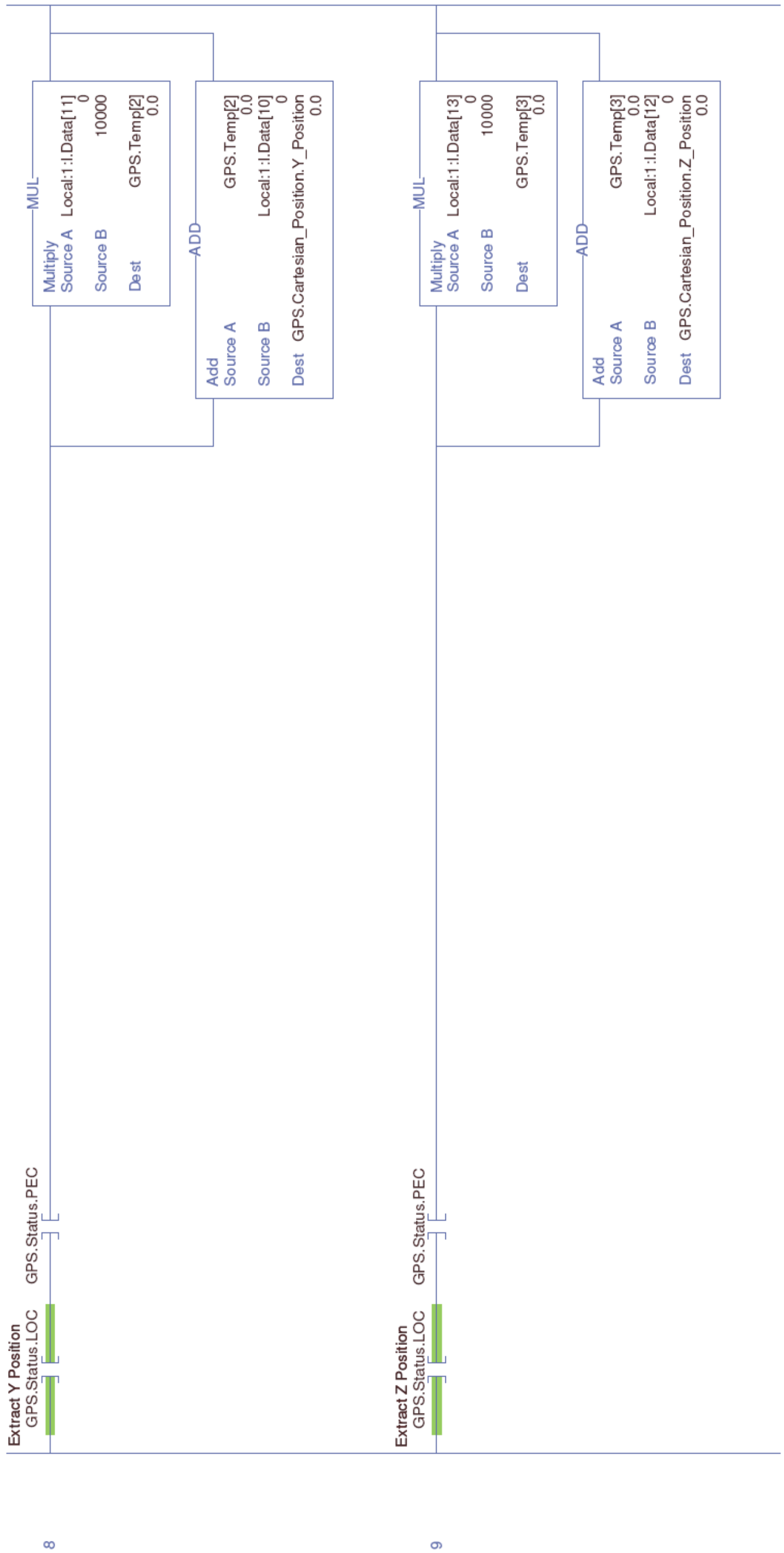
This Appendix provides a detailed description of recommended data structures that can be used in conjunction with the provided example ladder logic given below. The following example code (and structures) can be downloaded from the Hiprom website. (www.hiprom.com).

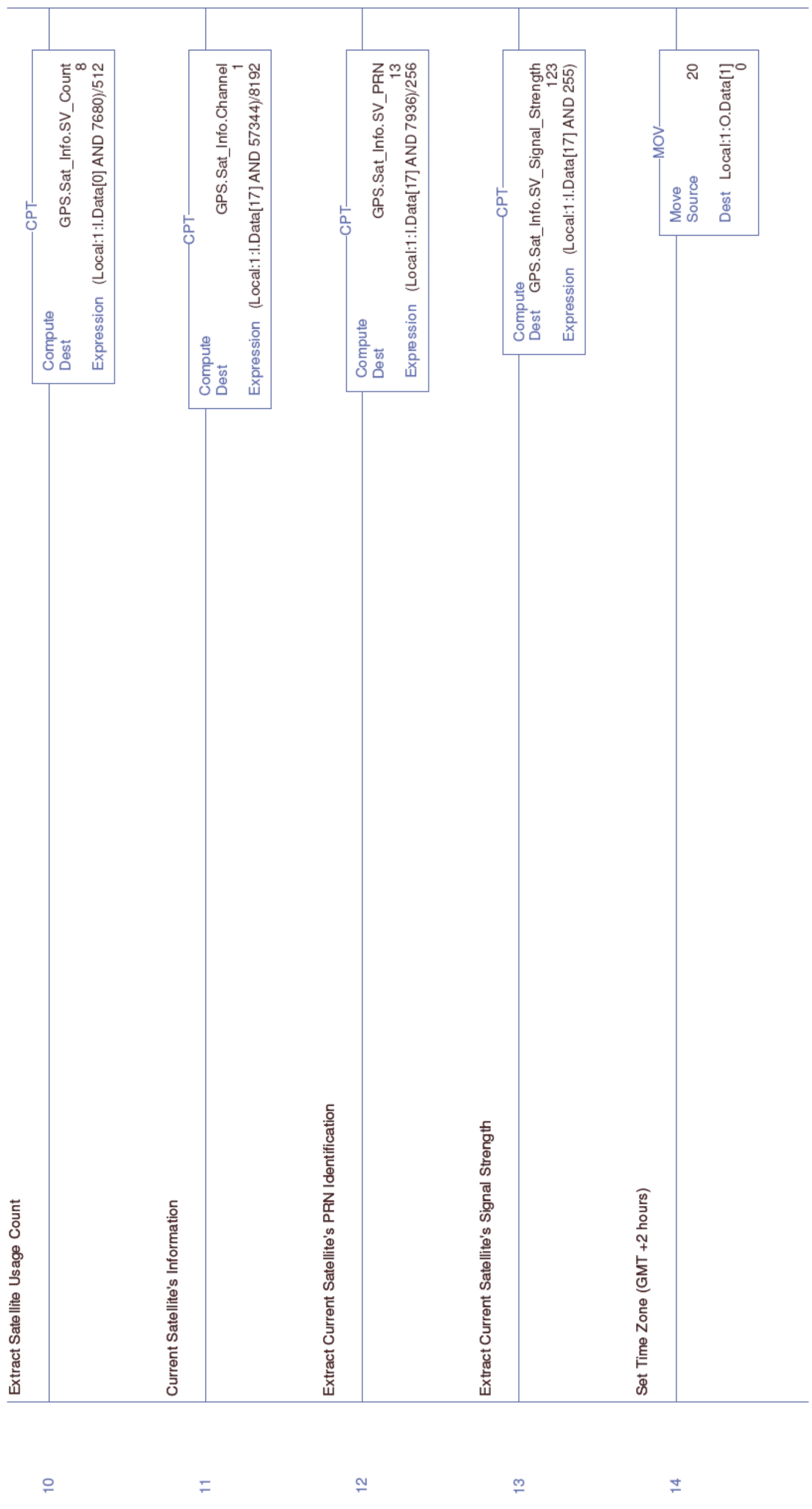

0
Copy GPS Module Status to GPSStatus Structure
COP
Copy File
Source Local:1:I.Data[0]
Dest GPS.Status
Length 1
1
Copy GPS Module Time to GPSTime Structure
COP
Copy File
Source Local:1:I.Data[1]
Dest GPS.Time
Length 1
2
Copy GPS Module Polar Velocity
GPS.Status.LOC
GPS.Status.PEC
COP
Copy File
Source Local:1:I.Data[14]
Dest GPS.Polar_Velocity
Length 1
3
Copy GPS Module Cartesian Velocity
GPS.Status.LOC
GPS.Status.PEC
COP
Copy File
Source Local:1:I.Data[14]
Dest GPS.Cartesian_Velocity
Length 1


4
Extract Latitude Degrees, Minutes and Seconds
GPS.Status.LOC
GPS.Status.PEC
DIV
Divide
Source A Local:1:I.Data[9]
0
Source B 60
Dest GPS.Polar_Position.Latitude_Degrees
26
CPT
Compute
Dest GPS.Polar_Position.Latitude_Minutes
6
Expression Local:1:I.Data[9] - (GPS.Polar_Position.Latitude_Degrees * 60)
ADD
Add
Source A GPS.Polar_Position.Latitude_Minutes
6
Source B 60
Dest GPS.Polar_Position.Latitude_Minutes
6
LES
Less Than (A<B)
Source A GPS.Polar_Position.Latitude_Minutes
6
Source B 0
SUB
Subtract
Source A GPS.Polar_Position.Latitude_Degrees
26
Source B 1
Dest GPS.Polar_Position.Latitude_Degrees
26
DIV
Divide
Source A Local:1:I.Data[8]
0
Source B 100
Dest GPS.Polar_Position.Latitude_Seconds
7.74


5
Extract Longtitude Degrees, Minutes and Seconds
GPS.Status.LOC
GPS.Status.PEC
DIV
Divide
Source A Local:1:I.Data[11]
0
Source B 60
60
Dest GPS.Polar_Position.Longtitude_Degrees
27
CPT
Compute
Dest GPS.Polar_Position.Longtitude_Minutes
59
Expression Local:1:I.Data[11] - (GPS.Polar_Position.Longtitude_Degrees * 60)
LES
Less Than (A<B)
Source A GPS.Polar_Position.Longtitude_Minutes
59
Source B 0
0
ADD
Add
Source A GPS.Polar_Position.Longtitude_Minutes
59
Source B 60
60
Dest GPS.Polar_Position.Longtitude_Minutes
59
SUB
Subtract
Source A GPS.Polar_Position.Longtitude_Degrees
27
Source B 1
1
Dest GPS.Polar_Position.Longtitude_Degrees
27
DIV
Divide
Source A Local:1:I.Data[10]
0
Source B 100
100
Dest GPS.Polar_Position.Longtitude_Seconds
42.59


6
Extract Altitude
GPS.Status.LOC
GPS.Status.PEC
MUL
Multiply
Source A Local:1:I.Data[13]
0
Source B 10000
Dest GPS.Temp[0]
0.0
ADD
Add
Source A Local:1:I.Data[12]
0
Source B GPS.Temp[0]
0.0
Dest GPS.Polar_Position.Altitude
1580.0
7
Extract X Position
GPS.Status.LOC
GPS.Status.PEC
MUL
Multiply
Source A Local:1:I.Data[9]
0
Source B 10000
Dest GPS.Temp[1]
0.0
ADD
Add
Source A GPS.Temp[1]
0.0
Source B Local:1:I.Data[8]
0
Dest GPS.Cartesian_Position.X_Position
0.0


8
Extract Y Position
GPS.Status.LOC
GPS.Status.PEC
MUL
Multiply
Source A Local:1:I.Data[11]
0
Source B 10000
Dest GPS.Temp[2]
0.0
ADD
Add
Source A GPS.Temp[2]
0.0
Source B Local:1:I.Data[10]
0
Dest GPS.Cartesian_Position.Y_Position
0.0
9
Extract Z Position
GPS.Status.LOC
GPS.Status.PEC
MUL
Multiply
Source A Local:1:I.Data[13]
0
Source B 10000
Dest GPS.Temp[3]
0.0
ADD
Add
Source A GPS.Temp[3]
0.0
Source B Local:1:I.Data[12]
0
Dest GPS.Cartesian_Position.Z_Position
0.0


10
Extract Satellite Usage Count
CPT
Compute
Dest GPS.Sat_Info.SV_Count
8
Expression (Local:1:I.Data[0] AND 7680)/512
11
Current Satellite's Information
CPT
Compute
Dest GPS.Sat_Info.Channel
1
Expression (Local:1:I.Data[17] AND 57344)/8192
12
Extract Current Satellite's PRN Identification
CPT
Compute
Dest GPS.Sat_Info.SV_PRN
13
Expression (Local:1:I.Data[17] AND 7936)/256
13
Extract Current Satellite's Signal Strength
CPT
Compute
Dest GPS.Sat_Info.SV_Signal_Strength
123
Expression (Local:1:I.Data[17] AND 255)
14
Set Time Zone (GMT +2 hours)
MOV
Move
Source 20
Dest Local:1:O.Data[1]
0

A.2.1. Recommended Input Image Structures

Data of the 1769HP-GPS can be presented clearly by manipulating and copying the input image to the GPS user-defined data type (UDT) structure. This structure utilizes the following embedded UDT structures (detailed below)

- GPS_Status
- GPS_Satellite_Information
- GPS_Time
- GPS_Polar_Position
- GPS_Cartesian_Position
- GPS_Polar_Velocity
- GPS_Cartesian_Velocity

GPS		
Name	**Data Type**	**Style**
Status	GPS_Status	Decimal
Sat_Info	GPS_Satellite_Information	Decimal
Time	GPS_Time	Decimal
Polar_Position	GPS_Polar_Position	Decimal
Cartesian_Position	GPS_Cartesian_Postion	Decimal
Polar_Velocity	GPS_Polar_Velocity	Decimal
Cartesian_Velocity	GPS_Cartesian_Velocity	Decimal
Temp	REAL[4]	Float

Table A.1 : GPS UDT

GPS_Status		
Name	**Data Type**	**Style**
SKY	BOOL	Decimal
LOC	BOOL	Decimal
DIFF	BOOL	Decimal
PPS	BOOL	Decimal
PDP	BOOL	Decimal
BAT	BOOL	Decimal
ANT	BOOL	Decimal
RSV	BOOL	Decimal
DTV	BOOL	Decimal
SVCOUNT	BOOL	Decimal
SVCOUNT1	BOOL	Decimal
SVCOUNT2	BOOL	Decimal
SVCOUNT3	BOOL	Decimal
PEC	BOOL	Decimal
EWH	BOOL	Decimal
NSH	BOOL	Decimal

Table A.2 : GPS_Status UDT

GPS_Satellite_Information		
Name	**Data Type**	**Style**
SV_Count	INT	Decimal
Channel	INT	Decimal
SV PRN	INT	Decimal
SV_Signal_Strength	INT	Decimal

Table A.3 : GPS_Satellite_Information UDT

GPS_Time		
Name	**Data Type**	**Style**
MilliSecond	INT	Decimal
Second	INT	Decimal
Minute	INT	Decimal
Hour	INT	Decimal
Day	INT	Decimal
Month	INT	Decimal
Year	INT	Decimal

Table A.4 : GPS_Time UDT

GPS_Polar_Position		
Name	**Data Type**	**Style**
Latitude_Degrees	INT	Decimal
Latitude_Minutes	INT	Decimal
Latitude_Seconds	REAL	Float
Longtitude_Degrees	INT	Decimal
Longtitude_Minutes	INT	Decimal
Longtitude_Seconds	REAL	Float
Altitude	REAL	Float

Table A.5 : GPS_Polar_Position UDT

GPS_Cartesian_Position		
Name	**Data Type**	**Style**
X_Position	REAL	Float
Y_Position	REAL	Float
Z_Position	REAL	Float

Table A.6 : GPS_Cartesian_Position UDT

GPS_Polar_Velocity		
Name	**Data Type**	**Style**
Northerly_Velocity	INT	Decimal
Easterly_Velocity	INT	Decimal
Upward_Velocity	INT	Decimal

Table A.7 : GPS_Polar_Velocity UDT

GPS_Cartesian_Velocity		
Name	**Data Type**	**Style**
X_Velocity	INT	Decimal
Y_Velocity	INT	Decimal
Z_Velocity	INT	Decimal

Table A.8 : GPS_Cartesian_Velocity UDT

APPENDIX B SPECIFICATIONS

Parameter	Specification
General	
Module Location	Any Slot
Electrical	
Backplane Current	165mA @ 5.0V
Schedules Connection Paramters	
RPI	1ms to 750ms
GPS Receiver Specification	
General	L1 frequency (1575.42 MHz), C/A code (Standard
	Positioning Service), 8-channel, continuous tracking receiver,
	32 correlators
Accuracy Horizontal	<6 meters (50%), <9 meters (90%)
Altitude	<11 meters (50%), <18 meters (90%)
Time	±1ms (±1 RPI)
Hot Start	<14 sec. (50%), <18 sec. (90%)
Warm Start	<38 sec. (50%), <45 sec. (90%)
Cold Start	<90 sec. (50%), <170 sec. (90%)
Active Antenna	
Antenna Connector	SMA female connector
Frequency Range	1575.42 MHz ± 1.023 MHz
Polarization	Right-hand circular polarization (RHCP)
Output Impedance	50Ω
VSWR	2.0 maximum
Axial Ratio	90°: 4.0 dB maximum; 10°: 6 dB maximum
Gain	35 dB ± 3 dB
Out of Band Rejection	fo: 1575.42 MHz
	fo ± 20 MHz : 7dB min
	fo ± 30 MHz : 12dB min
	fo ± 40 MHz : 20dB min
	fo ± 100 MHz : 100dB min
Azimuth Coverage	360° (omni-directional)
Elevation Coverage	0° to 90° elevation (hemispherical)
Antenna Patch Lead	
Coax Type	RG-58
Impedance	50Ω

APPENDIX C GPS OPERATION

The Global Positioning System (GPS) is a satellite based navigation system operated and maintained by the U.S. Department of Defence. The system consists of a constellation of 24 satellites providing world-wide, 24 hour, three dimensional (3D) coverage. Although originally conceived for military needs, GPS has a broad array of civilian applications including surveying, marine, land, aviation, and vehicle navigation. GPS is the most accurate technology available for vehicle navigation.

C.1 GPS Satellite Message

Every GPS satellite transmits the Coarse/Acquisition (C/A) code and satellite data modulated onto the L1 carrier frequency (1575.42 MHz). The satellite data transmitted by each satellite includes a satellite almanac for the entire GPS system, its own satellite ephemeris and its own clock correction.

The satellite data is transmitted in 30-second frames. Each frame contains the clock correction and ephemeris for that specific satellite ,and two pages of the 50-page GPS system almanac. The almanac is repeated every 12.5 minutes. The ephemeris is repeated every 30 seconds. The system almanac contains information about each of the satellites in the constellation, ionospheric data, and special system messages. The GPS system almanac is updated weekly and is typically valid for months. The ephemeris contains detailed orbital information for a specific satellite. Ephemeris data changes hourly, but is valid for up to four hours. The GPS control segment updates the system almanac weekly and the ephemeris hourly through three ground-based control stations. During normal operation, the 1769HP-GPS receiver module updates its ephemeris and almanac as needed. The performance of a GPS receiver at power-on is determined largely by the availability and accuracy of the satellite ephemeris data and the availability of a GPS system almanac.

C.2 Satellite Acquisition and Time to First Fix

Cold-Start

The term “cold-start” describes the performance of a GPS receiver at power-on when no navigation data is available. “cold” signifies that the receiver does not have a current almanac, satellite ephemeris, initial position, or time. The cold-start search algorithm applies to a 1769HP-GPS receiver which has no memory of its previous session (i.e., is powered on without the memory backup circuit connected to a source of DC power). This is the “out of the box” condition of the GPS module as received from the factory. In a cold-start condition the receiver automatically selects a set of eight satellites and dedicates an individual tracking channel to each satellite, to search the Doppler range frequency for each satellite in the set. If none of the eight selected satellites is acquired after a predetermined period of time (time-out), the receiver will select a new search set of eight satellites and will repeat the process, until the first satellite is acquired. As satellites are

acquired, the receiver automatically collects ephemeris and almanac data. The GPS receiver uses the knowledge gained from acquiring a specific satellite to eliminate other satellites, those below the horizon, from the search set. This strategy speeds the acquisition of additional satellites required to achieve the first position fix. The cold-start search sets are established to ensure that at least three satellites are acquired within the first two time-out periods. As soon as three satellites are found, the receiver will compute an initial position fix. The typical time to first fix is less than 2 minutes. A complete system almanac is not required to achieve a first position fix. However, the availability and accuracy of the satellite ephemeris data and the availability of a GPS almanac can substantially shorten the time to first fix.

Warm Start

In a warm-start condition the receiver has been powered down for at least one hour but has stored a current almanac, an initial position, and time, in memory. When connected to an external back-up power source (battery back-up), the 1769HP-GPS receiver retains the almanac, approximate position, and time to aid in satellite acquisition and reduce the time to first fix.

During a warm start, the 1769HP-GPS receiver identifies the satellites which are expected to be in view, given the system almanac, the initial position and the approximate time. The receiver calculates the elevation and expected Doppler shift for each satellite in this expected set and directs the eight tracking channels in a parallel search for these satellites. The warm start time to first fix, when the receiver has been powered down for more than 60 minutes (i.e. the ephemeris data is old), is usually less than 45 seconds.

Hot Start

A hot start strategy applies when the 1769HP-GPS receiver has been powered down for less than 60 minutes, and the almanac, position, ephemeris, and time are valid. The hot start search strategy is similar to a warm start, but since the ephemeris data in memory is considered current and valid, the acquisition time is typically less than 20 seconds.

C.3 Satellite Mask Settings

Once the 1769HP-GPS receiver has acquired and locked onto a set of satellites, which pass the mask criteria listed in this section, and has obtained a valid ephemeris for each satellite, it will output regular position, velocity and time reports according to the protocol selected. The satellite masks used by the 1769HP-GPS receiver are listed in Table D.1. These masks serve as the screening criteria for satellites used in fix computations and ensure that position solutions meet a minimum level of accuracy. The 1769HP-GPS receiver will only output position, course, speed and time when a satellite set can be acquired which meets all of the mask criteria.

Parameter	Mask
Elevation	>5°
SnR	>3
PDOP	12

Table D.1 : Satellite Mask Limits

Elevation Mask

Satellites below a 5° elevation are not used in the position solution. Although low elevation satellites can contribute to a lower/better PDOP, the signals from low elevation satellites are poorer quality, since they suffer greater tropospheric and ionospheric distortion than the signals from higher elevation satellites. These signals travel further through the ionospheric and tropospheric layers. In addition, low elevation satellites can contribute to frequent constellation switches, since the signals from these satellites are more easily obscured by buildings and terrain. Constellation switches can cause noticeable jumps in the position output. Since worldwide GPS satellite coverage is generally excellent, it is not usually necessary to use satellites below a 5° elevation to improve GPS coverage time. In some applications, like urban environments, a higher mask may be warranted to minimize the frequency of constellation switches and the impact of reflected signals.

SNR Mask

Although the 1769HP-GPS receiver is capable of tracking signals with SNRs as low as 0, the default SNR mask is set to 3 to eliminate poor quality signals from the fix computation and minimize constellation switching. Low SNR values may result from:

- Low Elevation Satellites
- Partially Obscured Signals (e.g. Dense Foliage)
- Multi-Reflected Signals (Multi-Path)

The distortion of signals and the frequent constellation switches associated with low-elevation satellites were discussed above. In mobile applications, the attenuation of signals by foliage is typically a temporary condition. Since the 1769HP-GPS receiver can maintain lock on signals with SNRs as low as 0, it offers excellent performance when traveling through heavy foliage. Multi-reflected signals, also known as Multi-path, can degrade the position solution. Multi-path is most commonly found in urban environments with many tall buildings and a preponderance of mirrored glass, which is popular in modern architecture. Multi-reflected signals tend to be weak (low SNR value), since each reflection attenuates the signal. By setting the SNR mask to 3 the impact of multi-reflected signals is minimized.

DOP Mask

Position Dilution of Precision (DOP) is a measure of the error caused by the geometric relationship of the satellites used in the position solution. Satellite sets which are tightly clustered or aligned in the sky will have a high DOP and will contribute to a lower position accuracy. For most applications, a DOP mask of 12 offers a satisfactory trade-off between accuracy and GPS coverage time.

Position Accuracy

GPS position accuracy is degraded by atmospheric distortion, satellite geometry, satellite clock errors, and receiver clock errors. Effective models for atmospheric distortion of satellite signals have been developed to minimize the impact of tropospheric and ionospheric effects. The impact of satellite clock errors is minimized by incorporating the clock corrections transmitted by each satellite used in the position solution.

GPS Timing

In many timing applications, such as time/frequency standards, site synchronization systems and event measurement systems, GPS receivers are used to discipline local oscillators. The GPS constellation consists of 24 orbiting satellites. Each GPS satellite contains a highly-stable atomic (Cesium) clock, which is continuously monitored and corrected by the GPS control segment. Consequently, the GPS constellation can be considered a set of 24 orbiting clocks with worldwide 24-hour coverage. GPS receivers use the signals from these GPS “clocks” to correct its internal clock, which is not as stable or accurate as the GPS atomic clocks. In addition to serving as a highly accurate stand-alone time source, GPS receivers are used to synchronize distant clocks in communication or data networks. This synchronization is possible since all GPS satellite clocks are corrected to a common master clock. Therefore, the relative clock error is the same, regardless of which satellite or satellites are used. For timing applications requiring a “common clock”, GPS is the ideal solution. The position and time errors are related by the speed of light. Therefore, a position error of 100 meters corresponds to a time error of approximately 333 ns.

APPENDIX D TIME STANDARDS

There are many different time standards used in the world today. This chapter describes the different formats and standards used in the 1769HP-GPS module and how the relate to one another.

D.1 GPS Time

By synchronizing with the atomic clocks on GPS satellites the 1769HP-GPS module is able to compute accurate GPS time. GPS time differs from UTC (Universal Coordinated Time) by a variable integer number of seconds:

UTC = (GPS time) - (GPS UTC Offset)

As of April 2002, the GPS UTC offset was 13 seconds. The offset increases by 1 second approximately every 18 months. The 1769HP-GPS module automatically acquires the UTC offset from the received GPS system almanac and calculates the correct UTC.
The 1769HP-GPS receiver makes use of the Extended GPS Week Number as the absolute number of weeks since the beginning of GPS time or January 6, 1980. Using this, rather than the true GPS Week Number prevents any possible roll-over issues (similar to Y2K), that earlier generation GPS receivers suffered from.

D.2 Universal Coordinate Time (UTC)

Universal Coordinate Time (UTC) is the world standard maintained by an ensemble of atomic clocks operated by government organizations around the world. UTC time replaced GMT (Greenwich Mean Time) as the world standard, in 1986. GPS time is steered relative to Universal Coordinated Time (UTC). GPS does not recognize leap seconds resulting in the aforementioned GPS UTC Offset. The 1769HP-GPS module reports UTC as a 64 bit unsigned long integer representing the number of elapsed microseconds since 1 January 1972. This UTC value is thus independent of the Configured Time Zone.

D.3 Local Time and Time Zone Configuration

Local time is expressed in Gregorian format and takes into account the configured Time Zone. The Time Zone is the difference between local and UTC time expressed as a REAL number of hours.

APPENDIX E GLOSSARY

Communications format
Format that defines the type of information transferred between an I/O module and its owner controller. This format also defines the tags created for each /O module

Download
The process of transferring the contents of a project on the workstation into the controller

Earth-Centered-Earth-Fixed (ECEF) coordinates
Cartesian coordinate system where the X direction is the intersection of the prime meridian (Greenwich) with the equator. The vectors rotate with the earth. Z is the direction of the spin axis, with positive through the north pole.

GPS (Global Positioning System)
A constellation of 24 radio navigation (not communication) satellites which transmit signals used (by GPS receivers) to determine precise location (position, velocity, and time) solutions. GPS signals are available world-wide, 24 hours a day, in all weather conditions. This system also includes 5 monitor ground stations, 1 master control ground station, and 3 upload ground stations.

GPS Antenna
An antenna designed to receive GPS radio navigation signals. These antennas typically comprise a Low Noise Amplifier (LNA) and are known as active, and thus require DC power.

GPS Processor
An electronic device that interprets the GPS radio navigation signals (received by a GPS antenna) and determines a location solution.

GPS Receiver
The combination of a GPS antenna and a GPS processor.

Owner controller
The controller that creates and stores the primary configuration and communication connection to a module

PDOP Position Dilution of Precision.
PDOP is a unitless figure of merit that describes how an uncertainty in pseudo-range affects position solutions.

PRN Pseudo-random noise.
Each GPS satellite generates its own distinctive PRN code, which is modulated onto each carrier. The PRN code serves as identification of the satellite, as a timing signal, and as a subcarrier for the navigation data.

Producer/consumer
Intelligent data exchange system devices in which the GPS module produces data without having been polled first.

Requested packet interval (RPI)
A configurable parameter which defines when the module will multicast data

Service
A system feature that is performed on user demand

Signal to noise ratio
A measure of the relative power levels of a communication signal and noise on a data line. SNR is expressed in decibels (dB).

SV
Space Vehicle (GPS satellite).

Tag
A named area of the controller's memory where data is stored like a variable

End of Document